92-03775/

The cover graphic is based on an ancient Egyptian hieroglyph representing the all-seeing eye of the powerful sky god, Horus. Segments of this "eye in the sky" became hieroglyphic signs for measuring fractions in ancient Egypt. Intriguingly, however, the sum of the physical segments adds up to only 63/64 and, thus, never reaches the equivalent of the whole or perfection. Similarly, verification is unlikely to be perfect.

Today, a core element in the multilateral arms control verification process is likely to be the unintrusive "eye in the sky", or space-based remote sensing system. These space-based techniques will have to be supplemented by a package of other methods of verification such as airborne and ground-based sensors as well as some form of on-site inspection (OSI) and observations. All these physical techniques add together, just as the fractions of the eye of Horus do, to form the "eye" of verification. Physical verification, however, will not necessarily be conclusive, and there is likely to remain a degree of uncertainty in the process. Adequate and effective verification, therefore, will still require the additional, non-physical, element of judgement, represented by the unseen fraction of the eye of Horus.

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Verifying Limitations on Military Personnel

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Abstract

This paper examines issues relating to the problems of verifying agreements to reduce or limit military personnel. After a brief survey of historical examples of attempts to verify personnel and related limitations, the report focuses on the special characteristics of military personnel that will affect verification. Possible verification methods are reviewed and assessed, including records monitoring, on-site inspections, remote and short-range sensors, and special identity cards. The paper continues with a discussion of the relationship between personnel verification and the degree of information exchanged. Several areas for future research are suggested including possible field trials of the applicability of various verification methods.

Résumé

Les auteurs du document examinent les problèmes que présente la vérification du respect des accords portant sur la réduction ou la limitation du personnel militaire. Après avoir brièvement présenté quelques exemples historiques de situations où l'on a tenté de vérifier si des limites visant du personnel et des ressources connexes avaient été observées, les auteurs mettent l'accent sur les caractéristiques spéciales du personnel qui vont influer sur la vérification. Ils examinent et évaluent des méthodes de vérification possibles, y compris le contrôle des registres, les inspections sur place, l'utilisation de capteurs à courte portée et de télédétecteurs, et le recours à des cartes d'identité spéciales. Le document présente ensuite une discussion sur les rapports existant entre la vérification du personnel et la quantité des renseignements échangés. Les auteurs proposent divers thèmes de recherche pour l'avenir, dont des essais sur le terrain pour mesurer l'applicabilité de diverses méthodes de vérification.

Preface

The Conventional Forces in Europe (CFE) Treaty signed on 19 November 1990 calls on the parties to continue negotiations with the goal of building upon that disarmament agreement. These on-going negotiations — often called the CFE 1A negotiations — has as one agenda item: "measures to limit the personnel strength" of conventional armed forces within the Atlantic-to-the-Urals (ATTU) zone. The CFE 1A talks aim to reach agreement before the Helsinki Follow-up Meeting of the Conference on Security and Cooperation in Europe (CSCE) slated for the spring of 1992.

Verifying limitations on military personnel, whether in the CFE or other contexts, will not be easy and will likely involve its own unique characteristics. Unlike much of the military equipment (such as missiles and tanks), which to-date have been the focus of arms control and disarmament efforts, personnel seems, at first glance, less susceptible to traditional verification methods. This is true because military personnel are much harder to count with any precision, especially from a distance. There may also be significant definitional problems because of differences in force structures between nations, particularly the greater reliance by some countries on reserve and paramilitary forces.

It can also be argued that military personnel constitutes a threat only when combined with modern equipment. Consequently, it might be sufficient to focus verification efforts only on those personnel directly associated with such equipment. If so, then the verification of personnel limitations might rely extensively on the provisions already set up to verify treaty limited equipment (TLE) under the CFE Treaty.

Verification systems based on tags, identity cards or other individual tracking methods are also feasible but may be expensive, administratively cumbersome, time consuming and not foolproof. Administrative, personnel and other records may provide an additional source of useful information on personnel levels, but again with similar caveats.

In part because of the difficulties foreseen in verifying personnel limitations, it is sometimes argued that such limitations should take the form of politically binding rather than legally binding obligations. According to this view, politically binding obligations do not require the same standard of verification as do legally binding ones. Under the Stockholm Document of 1986, for example, the politically binding Confidence and Security Building Measures (CSBM) incorporated therein did not require the same stringency of verification as do the obligations of the CFE Treaty with the latter's focus on reducing military

equipment, which goes to the very heart of North Atlantic Treaty Organization (NATO) security.

This argument could be misleading, however. It is, perhaps, not the legal nature of the obligation that is important in determining verification standards, but rather the judgement of the parties concerning the military and political importance to their national security of the obligations that are being undertaken.

There is a belief in many quarters that verification of personnel limitations is impossible. While acknowledging the difficulties, such a judgement may be premature. The potential significance of successful violations of personnel restrictions, especially as military forces generally decrease in numbers, would seem to warrant careful examination of issues surrounding personnel verification.

Unfortunately, there seems to have been little serious study of personnel verification reported in the open literature; a rather astonishing fact given the focus of the Mutual and Balanced Force Reduction (MBFR) talks on military personnel for over 15 years, beginning in 1973. A few studies in the 1960s were undertaken, primarily in the context of a hypothetical arms control agreement that would be broader than personnel alone, encompassing military equipment as well.

It is, in part, because of this surprising paucity of recent critical evaluations of personnel verification that Dr. George Lindsey (Senior Research Fellow) and Mr. Alex Morrison (Executive Director) of the Canadian Institute for Strategic Studies were invited to undertake an initial examination of issues relating to this question, as part of Canada's Verification Research Program.

Their report constitutes a unique examination of personnel verification that has relevance beyond the on-going discussions respecting personnel limitations in Europe to include other regional contexts as well. As the international system evolves towards what President George Bush has termed a "new world order", agreeing to limit military personnel in one form or another may become increasingly topical. This research report should assist in discussions of the verification aspects of such personnel limitations.

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List of Abbreviations

ACV	Armoured Combat Vehicle
ARTY	Artillery
ATTU	Atlantic-to-the-Urals (Zone)
CFE	Conventional Forces in Europe (CFE Treaty, signed 19 November 1990; CFE 1A negotiations followed on from this Treaty)
CSBM	Confidence and Security Building Measures
CSCE	Conference on Security and Cooperation in Europe
EEP	Entry/Exit Point
IAEA	International Atomic Energy Agency
ICBM	Intercontinental Ballistic Missile
ID Card	Identity Card
INF	Intermediate Nuclear Forces
INFY	Infantry
km	kilometre
m	metre
MBFR	Mutual and Balanced Force Reduction (Talks)
MBT	Main Battle Tank
"MILPER"	Military Personnel (Card)
MR	Motorized Rifle (Division)
NATO	North Atlantic Treaty Organization
NTM	National Technical Means

OSI	On-site Inspection
PPM	Perimeter and Portal Monitoring
SALT	Strategic Arms Limitation Treaty (SALT I: signed 26 May 1972 and entered into force 3 October 1972; SALT II: signed 18 June 1979)
START	Strategic Arms Reduction Treaty (signed 31 July 1991)
TLE	Treaty Limited Equipment
TOE	Table of Organization and Equipment
UN	United Nations
UNSCOM	United Nations Special Commission
WEU	Western European Union

I. Introduction

The recent successful conclusion of several negotiations to control and limit nuclear and conventional weapons and equipment has caused attention to be focused anew on possible future reduction and control of military personnel. There is, however, disagreement as to whether personnel reductions can be verified to the same extent as reductions in weapons and equipment. There are also schools of thought which hold that if weapons are adequately controlled, then personnel need not be limited. Others suggest that the world political and military climate has improved so positively that verification is no longer necessary, or perhaps even negotiated arms control itself.

Very little has been written in the open literature about personnel verification. It would appear, however, given the renewed interest in limitations on military personnel such as in the context of the Conventional Forces in Europe (CFE) talks, that this is an area which warrants some research, speculation, and testing. If there is to be any degree of confidence that parties to agreements on the reduction or limitation of personnel are complying with their undertakings, then there must be a capability to achieve an acceptable level of verification. Recognizing this, it is not impossible that the requirements of adequate verification will be judged to be too difficult, too intrusive, or too expensive to be acceptable.

On 7 December 1988, during the course of its 43rd Session, the United Nations General Assembly adopted a set of 16 verification principles[1]. These principles were the outcome of a working group chaired by Canada at the 1987 and 1988 sessions of the United Nations Disarmament Commission. The first principle affirms that: "Adequate and effective verification is an essential element of all arms limitation and disarmament agreements." Other principles refer to the need to employ different techniques, including on-site inspection (OSI); to the benefits to be derived from greater openness; to the desirability of non-interference in the process of verification; that verification is an activity conducted by the parties to an agreement or by an organization at the request of the parties; and that verification arrangements must provide clear and timely evidence of compliance or non-compliance. Any verification regime designed to verify personnel levels should be constructed bearing in mind these principles.

In the past, considerable international discussion has been conducted regarding personnel limitations. Of most current relevance, however, are developments with respect to arms control in Europe. Article XVIII of the CFE Treaty, signed in Paris on 19 November 1990, refers to follow-on talks and states that:

"The objective for these negotiations shall be to conclude an agreement on additional measures aimed at further strengthening security and stability in Europe, and pursuant to the Mandate, *including measures to limit the personnel strength of their conventional armed forces within the area of application.*" (Emphasis added).

It is clear from the interest that has been shown in the European talks that the subject of personnel reductions is one that is being followed with great care and concern by states in at least one area of the world. It is appropriate, however, that a study of the challenges and opportunities inherent in the verification of personnel levels ought to be general enough to have potential application throughout the world, including in peacekeeping contexts. The recent case of the United Nations Special Commission (UNSCOM), established after the Gulf War pursuant to Security Council Resolution 687 (1991) to monitor Iraqi compliance with various disarmament measures, is indicative of the demands which are likely to be placed increasingly on the United Nations (UN) with respect to arms control verification. In the future, such demands may well include verifying personnel limitations. Of course, there will have to be variations developed to meet local conditions in different regions, but most of the basic considerations and conclusions could be relevant to areas and situations beyond those of CFE.

The objective of this study is to examine the subject of limitations on military personnel, the methods by which an agreement to limit personnel could be verified, and the probable effectiveness of these methods. This study does not attempt to make a judgement as to the wisdom of negotiating limits on military personnel, but is confined to a preliminary consideration of whether effective verification of such an agreement is possible, and what would be the likely steps needed to carry it out.

II. A Brief History of Personnel Verification

In 1988, the Western European Union (WEU) prepared a paper[2] which examined the experiences of a number of agencies established in the past for the purpose of verifying agreements to restrict conventional forces and armaments. The discussion below draws on the main findings of the WEU paper with respect to each of the agencies' work in the area of verification of personnel, as well as on other sources.

The Interallied Control Commissions of 1920-1926

To oversee the application of the Versailles Treaty of 1919 and to prevent rearmament in Germany, Interallied Control Commissions (military, naval and air) were established. The Military Commission had the task, *inter alia*, of verifying personnel levels. The Military Commission, which is of most interest for this study, was unable to carry out its duties, chiefly because of the resistance of the German government and citizens. Other reasons for failure included:

> "The complexity of personnel controls and the near impossibility, without complete freedom of action and a large inspection staff, of determining during inspections whether illicit elements were or were not present;
>
> "The existence of paramilitary and the "Schutzpolizei" organizations which made it possible to conceal personnel or to speed up the training of new recruits;
>
> ...
>
> "The varied legal obstacles resulting from either the interpretation of the Treaty or conflicts it provoked with existing laws. These gave rise to obstacles to the right of inspection even though this right had been accepted;
>
> "The refusal to supply accurate statements on personnel numbers and equipment which could serve is a basis for verification."[3]

The German and Italian Armistice Commissions of 1940-1942

Following the capitulation of France in 1940, Germany and Italy set up Commissions to monitor certain military clauses of the Armistice agreements, under which military activities of France were to be severely controlled. The Commissions failed for reasons very similar to those responsible for the failure of the Interallied Commissions after the First World War, notably obstruction by

government officials and the difficulty of controlling transfers of personnel between military and civilian organizations[4].

Early Post-war Discussions on General and Complete Disarmament

For some years after World War II a variety of initiatives were launched, in the hope of preventing further wars. Before anything concrete was accomplished, the "Cold War" intervened, poisoning international relations and producing rearmament rather than disarmament. By the early 1960s, the main focus of discussions had changed from General and Complete Disarmament towards specific measures aimed at the abolition of nuclear weapons, prevention of surprise attack, limitation on strategic weapons, control of nuclear testing and nuclear proliferation, and chemical weapons.

In over 21,000 pages of "Documents on Disarmament"[5], covering the main international discussions from 1945 to 1982, the subject of personnel limitation often appears in the first few years after the war. But after 1952 personnel is hardly mentioned, until the discussions which led up the formal negotiations on Mutual and Balanced Force Reductions in 1973. Some discussion of the observation of personnel strength occurs after 1958, but in connection with measures to obtain warning of surprise attack rather than consideration of the verification of negotiated limitations. Personnel limitations were also mentioned in wider discussions relating to General and Complete Disarmament during the early 1960s.

In July 1950, the United States (USA) delegation to the Working Committee of the UN Commission for Conventional Armaments submitted a paper outlining the information which would need to be presented preliminary to inspection and verification of reductions in conventional armed forces[6]. Military and paramilitary forces were to be included, and extensive information on these military forces and their deployments was to be exchanged in the form of separate reports on personnel, deployment, material, bases and facilities. Verification focused on the review of a variety of records and on ground and aerial OSI as indicated in the following extract:

> "V. ITEMS TO WHICH ACCESS MUST BE PROVIDED IN THE VERIFICATION PHASE OF SAFEGUARDS
>
> "A. Personnel Report Verification
>
> 1. Personnel accounting systems
> 2. Disbursing records
> 3. Unit muster rolls
> 4. Medical records
> 5. Ration records

6. Military and paramilitary installations for direct count
7. Current laws governing military service
8. Charters and by-laws of national political organizations of a military or semi-military service
9. Records of membership, training, and equipment of organizations included in 8 above
10. Individual personnel on all levels within organizations on matters pertaining to personnel verification

"B. Material Report Verification

1. Tables of organization and equipment of units
2. Supply activities including contract, purchasing, storage, issue and custody record
3. Government operated production facilities
4. Bases for spot checks
5. Reserve and operational units for spot checks
6. Material disposition records

"C. Deployment Report Verification

1. Fuel consumption records of mobile units
2. Travel vouchers, troop train and convoy movement records
3. Bills of lading for material shipments
4. Operational casualty records
5. Spot checks of installations and units

"D. Base Report Verification

1. Barracks and housing areas
2. Physical properties including runways, shops, hangars, warehouses, tanks, drydocks, etc.
3. Sewage and waste material disposal facilities
4. Medical facilities
5. Numbers and types of communications installations
6. Records of coal, oil and electricity consumption
7. Aerial survey of surrounding areas
8. Records of components and raw materials imported for fabrication
9. Records of output
10. Personnel records."

Another USA paper submitted two years later presented proposals for progressive and continuing disclosure and verification[7]. Again, emphasis was placed on an extensive information exchange to be verified by records

monitoring and ground and aerial inspection. The following extract is indicative of these themes:

"PROPOSED STAGES OF DISCLOSURE AND VERIFICATION

Stage I

"Disclose
a. Overall personnel strength of regular and reserve military forces and paramilitary organizations, including training establishments and security and police forces, broken down into each category.
b. Location of all operational military installations.

"Verify
a. By examination and cross-checks of central records to include personnel, disbursement, medical and procurement supplemented by access to and spot checks of records at selected installations.
b. By direct examination of location, personnel used, power input and physical dimensions of installations.

(a) and (b): Inspectors will have access to entire national territory to extent necessary to determine that all facilities and installations have been declared. Aerial surveys will be permitted for same purpose and to same extent.

Stage II

"Disclose
a. Organization, composition and disposition of units making up overall strengths disclosed in stage I.

...

"Verify
a. By quantitative analysis of records pertaining to personnel, movement of units and administrative support supplemented by access to and spot checks of selected units and installations.

...

(a) and (b): By aerial survey as in stage I."

Clearly, such verification procedures would be very intrusive and costly, though given the wide scope of the limitations proposed and the potential significance of violations, such intrusion and costs may not have been thought

inordinate. Disappointingly, nothing came of these early proposals for personnel limits.

Exercise *First Look*

Between 1963 and 1966 the Field Operations Office of the USA Arms Control and Disarmament Agency carried out a series of field trials (known as *Cloud Gap*), as part of a program to develop and test techniques for verification of conventional ground and air forces[8]. The objectives of the last trial of the series, named Field Test 4, included estimation of personnel inventory. The locales of the tests were barracks compounds and local training areas, barracks area complexes, and major training areas. Some of the inspectors were given free access to all buildings and areas with the exceptions of specified "sanctuaries", some were forbidden access to the interiors of buildings other than those open to the public. The effectiveness of evasion was tested, but only for equipment. Different categories of information were declared to the inspectors: accurate, false, and true. Averaged over the whole trial, the inspectors managed to count about 60 percent of the troops actually present, and their estimate of the total number was close (104 percent) to the true figure for the barracks complexes, low (78 percent) for the major training areas, and high (126 percent) for the barracks compounds.

The investigations were extended with a major joint exercise named Field Test 15, or *First Look*, carried out in cooperation with the British, in 1968[9]. The members of the verification teams combined the methods of "human observers, long-range detection systems, and aerial means of observation." It is noteworthy that the review of records was not one of the methods used in this test. The success in estimating the number of company equivalents was poor, with the estimates being seriously lower than the actual figure. The accuracy of estimating equipment levels was comparable, except that the unattended sensors proved able to detect nearly all vehicles, and all aircraft.

The authors of the WEU paper drew the following conclusions about this exercise:

> "a) The average error made by each inspection team in estimating the battle order was 20 percent, even for the small teams which had "limited" access to the establishments. Certain teams with "restricted" access had a 50 percent error rate.
>
> "b) The large teams with restricted access did better than small teams with restricted access. The large teams with limited access did no better than small teams with limited access.

"c) The results of the aerial observations improved the performance of the teams when they were available to them.

"d) The remotely-controlled systems did not provide very convincing results. They could probably have been used more effectively had they been placed around some of the restricted access installations.

"e) The rules for evaluating the collected data were inadequate. The teams were not sufficiently coordinated. A precise and detailed methodology would have been needed for collecting and processing data on a day-to-day basis: since no such methodology existed, the conclusions to be drawn from this exercise remain unclear."[10]

Perhaps the most useful conclusion of the WEU paper is :

"...the success of verification operations requires a willingness on the part of the signatories and all their representatives to submit to controls with goodwill in complying with their undertakings."

Patricia Lewis observes that "the most important conclusion for negotiators and implementation groups is that inspectors, even those with a high degree of access, cannot be expected to report the items of inventory with 100 percent total accuracy."[11] This is particularly important given that such detailed examination of sites will be limited only to a sample of all the sites containing forces subject to limitation. It seems likely that such observations would apply in even stronger terms when the focus of the verification effort is on military personnel.

The MBFR Negotiations

The Mutual and Balanced Force Reduction (MBFR) negotiations made little headway in the area of verification of personnel levels. There were certain principles set out by each of the sides, but political considerations, including the inability of the sides to agree on basic numbers frustrated any real progress[12].

It is likely that the regrettable failure to complete an agreement after 15 years of MBFR, which foundered for many reasons, but was closely associated with the attempt to limit personnel, has inclined planners to regard the control of personnel as infeasible. However, conditions have changed drastically since the death of MBFR in 1989, and many things that were infeasible in the 1980s may be worthy of reconsideration in the present decade.

The final communiqué of the MBFR talks was issued on 2 February 1989, at the conclusion of the last meeting of the negotiators. It noted the failure to agree on a treaty but:

> "Nevertheless the positions of the two sides were brought closer on a number of matters. The participants accumulated valuable experience and received a clearer notion of what will be needed in order to achieve mutually acceptable and verifiable cuts and restrictions of armed forces and armaments in Europe."

During the course of the MBFR negotiations, many suggestions for verification methods were put forward by each side. These suggestions may prove valuable when establishing a personnel verification system. They include:

- Temporary and permanent entry and exit monitoring points;
- Extensive information exchanges;
- Non-interference with national technical means of verification;
- Use of observers to monitor actual changes in personnel levels; and
- On-site inspections.

Some of these "Associated Measures" are now incorporated in one form or another into the verification regime for the CFE Treaty.

Peacekeeping

After the war between Egypt and Israel in 1973, a Field Mission was established to assist in monitoring the subsequent disengagement process in the Sinai[13]. The Sinai Field Mission and its successor — the Multi-national Force and Observers — pioneered the use of technology in the verification of peacekeeping agreements, notably ground based sensors at geographic choke points and aerial surveillance. The "Sinai Experience" also demonstrated the value of using an appropriate mix of technology for verification-like purposes. While a precedent setting development, it must be remembered that in the case of the Sinai what was being verified was the movement of small numbers of people, in a sparsely populated region, rather than the measurement of the numerical strength of large forces.

The recent activities of the UN Special Commission charged with verifying Iraqi compliance with Security Council Resolution 687 (1991), also seem likely to underline how the judicious use of a variety of verification methods, operating in a complementary fashion, is important for success. The Commission's activities are demonstrating as well the high level of intrusion that may be necessary for adequate verification of certain disarmament measures relating to nuclear materials, chemical and biological weapons, and ballistic

missiles (particularly when the party being verified is less than fully cooperative).

These examples are indicative of the growing realization by the international community that the UN has an important role to play in verification. There is also increasing awareness that contemporary technology can play a larger role in verification, reducing the number of and time spent by inspectors on the ground.

One of the main lessons from the more traditional peacekeeping operations which could be applicable to the verification of manning levels is that of close and continuous contact and liaison. Peacekeeping observers and force members are trained to acquire, maintain and enhance an intimate knowledge of the opposing forces which they are monitoring. Once the basic knowledge is gained, the maintenance of detail becomes much more routine. For the verification of personnel limitations this may mean that having permanent liaison officers from the verifying party stationed at diverse headquarters (to a relatively low organizational level) of the country whose forces are under scrutiny, may prove very efficacious.

If it were possible and desirable to transfer lessons from peacekeeping to verification of personnel levels, the implications for those countries with the greatest amount of experience and expertise in peacekeeping could be far-reaching. Such countries could be asked to formulate their experiences, devise plans for passing them on, implement these plans, and then be involved in the actual verification.

INF, START, CSCE and CFE

Some of the momentum lost by the MBFR negotiations was picked up by the Conference on Security and Co-operation in Europe (CSCE), and by the negotiations on Conventional Forces in Europe (CFE).

While the CSCE did not produce formal agreements for arms reductions with provisions for verification, the discussions on Confidence and Security Building Measures (CSBM) led to a greater willingness to consider some measures such as prior notification of certain military activities, improved contacts, steps to reduce risks, and, especially significant for the prospects of being able to verify personnel limitations, exchanges of information and arrangements for OSI and evaluations[14]. The evaluation visits contained in the Vienna Document of 1990 are particularly interesting from the perspective of personnel verification[15]. Under this portion of the Vienna Document each party is obliged to invite representatives of other parties to visit active formations and units at their normal peacetime locations with the aim of allowing the other

parties to evaluate the information provided in the information exchange portion of the Vienna Document (which includes data on personnel levels). While the frequency of such visits and their scope are quite limited, evaluation visits do provide an example of the type of inspection visits that could prove useful in assessing the numbers of military personnel stationed at a base or with a unit.

Although the Intermediate Nuclear Forces (INF), Strategic Arms Reduction (START), and CFE Treaties do not set limits on personnel, they contain exacting provisions for verification and the acceptance of intrusive inspections. The experience with these Treaties indicates that the parties are indeed willing to present extensive data regarding their armaments and to submit to intrusive inspections.

III. Some Factors Peculiar to the Verification of Personnel

The Large Numbers of Military Personnel

An agreement to limit military personnel poses different problems for verification than does one dealing with easily observable and identifiable weapons. One of the most important differences is the large number of personnel, as contrasted to major weapons, that are likely to be involved. Some 29 million persons were enroled in the active or reserve forces of 30 European countries in June 1991. Among the 23 countries who signed the CFE Treaty, a total of about 5,100,000 active army and air force personnel were stationed in the Atlantic-to-the-Urals (ATTU) area, approximately 1,850,000 of them in the crucial Central Region. Contrast these numbers with the limits agreed respecting military equipment under the CFE Treaty: 40,000 main battle tanks, 60,000 armoured combat vehicles (ACV), 40,000 artillery pieces, 13,600 fixed wing combat aircraft, and 4,000 attack helicopters.

Table 1 shows the numbers for military personnel in Europe, estimated for June 1991. All of the 29 million personnel (plus those recruited and trained since June 1990, and less those who have become unfit, died, or left the country) represent a pool of possible military personnel. So do the healthy civilians who could be enlisted and trained in the future. Most important for warning of surprise attack would be the number of active troops located in the Central Region, and while this is rapidly decreasing below the two million level, it will continue to remain at a large number as compared to a few tens of thousands of major weapons.

The Degree of Precision and Timeliness Needed for Verification of Personnel

For the purpose of establishing and assuring military stability in Europe, arms control must provide protection against two different possible threats. One is surprise attack, initiated with a minimum of warning and striking the opponent before he has had time to move out of his peacetime positions or assemble his reserves. In order to achieve surprise the aggressor will not be able to undertake large-scale visible preparations, or assemble significant reinforcements prior to the day of attack, and he will have to move forward quickly from his peacetime deployment areas.

Against this threat of surprise attack the primary measure of arms control is to reduce the offensive striking power of the forces stationed in forward positions. This will, of course, also reduce the defensive power of the opposing forces in their forward positions. However, the removal of forces from forward

positions should increase the time that would be needed to position troops for attack, and possibly afford time for the defenders to gather their strength to meet the assault.

Table 1:
Military Personnel in Europe

	Country of Origin	ATTU Total*	Central Region*	Total	
				Active	Reserves
Parties to CFE Treaty	Turkey	466,200		579,200	1,107,000
	Germany	438,700	438,700	476,300	1,009,000
	France	373,200	43,700	453,100	419,000
	Italy	312,400		361,400	584,000
	USA	273,400	227,400	2,029,600	1,712,700
	UK	228,400	63,400	300,100	347,200
	Spain	209,300		257,400	2,400,000
	Greece	139,000		158,500	406,000
	Netherlands	82,900	82,900	101,400	152,400
	Belgium	80,900	80,900	85,450	234,000
	Portugal	46,500		61,800	190,000
	Norway	25,400		32,700	285,000
	Denmark	24,400	24,400	29,400	72,700
	Canada	7,000	7,000	86,800	29,200
	Luxembourg			800	
	NATO Total	2,707,700	998,400	3,913,700	8,957,800
	USSR	1,583,000	373,000	3,400,000	5,239,000
	Poland	285,500	285,500	305,000	507,000
	Romania	181,600		200,800	626,000
	Czechoslovakia	132,100	132,100	154,000	495,000
	Bulgaria	97,000		107,000	472,500
	Hungary	86,500	86,500	86,500	210,000
	CFE Total	5,073,400	1,945,500	8,257,000	16,507,100
Other European	Yugoslavia			169,000	510,000
	Sweden			63,000	709,000
	Albania			48,000	155,000
	Austria			44,000	242,000
	Finland			31,800	700,000
	Ireland			12,900	16,100
	Cyprus			10,000	108,000
	Switzerland			3,500	625,000
	Malta			1,650	
	All Europe			8,599,850	19,573,200

Against the contingency of surprise attack the role of verification is to confirm that forces are not being strengthened beyond the agreed limits, especially in the forward areas, and especially as regards the type of unit designed for attack. Speed of detecting violations is more significant than precision. Imprecision of say ±25 percent in personnel count might be acceptable, but a delay of a few days in detecting a considerably larger build-up could leave the victim vulnerable in a surprise attack.

In addition to verification, CSBM such as notification of exercises and training periods for reserves could be important, particularly as they concern forward areas from which surprise attack could be mounted under the disguise of routine training.

The other threat to stability is that of mobilization of large forces for a heavy attack, in which the advantage of surprise would be foregone in the hope of obtaining decisive numerical superiority. To reduce this threat, arms control measures must limit the size and strength of active forces based in rear areas, and of reserve forces which could be mobilized. To verify that no such activities are under way will require monitoring of military activities in the rear areas, including depots and training centres as well as casernes.

Again, high precision is not required, but it would be important to become aware of a substantial build-up before many days had passed. General intelligence may be of more value than formal verification for this purpose, but the right to conduct inspections in rear areas should be established. As an indicator of preparation for major military activity, the ability to detect a build-up of personnel in rear areas may be as important as detection of the readying of armaments.

Categories of Uniformed Forces

Nearly all countries which have any armed forces at all have armies, air forces, and reserves. Most countries have navies, unless they happen to be landlocked. Quite a few have marines[16]. It would seem obvious that armies, navies, air forces, and marines qualify as military personnel in any categorization that would require verification (although some of them, such as navies, might be excluded in any particular treaty). There are a number of other categorizations peculiar to a few countries that also appear as unambiguously military personnel. Some of these are:

- Naval aviation (several countries);
- Strategic rocket forces (USSR);
- Air defence troops (USSR);

- Royal Air Force Regiment (UK); and
- Coast artillery (several countries).

Although all of these are unquestionably military, an agreement for personnel limitation could be made that excluded forces considered to be "purely defensive". The last three in the list above, and nearly all of those listed below, could qualify as purely defensive.

Civil defence and home guard organizations certainly have a role to play in a war, but would seem to be purely defensive, and perhaps not subject to limitation in personnel, although they could be used as a clandestine means of concealing military personnel. Some are labelled as:

- Territorial militia (Bulgaria);
- Citizens' militia (Poland);
- Civil defence troops (several countries);
- Naval home guard (Norway);
- Anti-aircraft home guard (Norway); and
- Voluntary auxiliary organization (Sweden).

In peacetime the guarding and policing of coastlines and land borders is often carried out by organizations that might be converted to a military role in the event of hostilities. Some of the relevant organizations are:

- Coast guard (several countries);
- Border guards (several countries);
- Naval public service force (France);
- Harbour control (Italy); and
- Civil air patrol (USA).

The line of demarcation between the military and the police forces is different in various countries. Some forces that appear to be primarily for policing duties, but could have some potential for conversion to military roles are:

- Gendarmerie (several countries);
- Carabinieri (Italy);
- Financial guards (Italy);
- National republican guard (Portugal);
- Guarda civile (Spain);
- Armed police (Cyprus);
- Milicija (Yugoslavia);
- Internal defence troops (Poland); and
- Royal Canadian Mounted Police.

While it is difficult to separate internal security from police work, the following examples seem to be primarily dedicated to internal security:

- KGB border guards (USSR)[17];
- MVD internal troops (USSR);
- Security police (Bulgaria);
- Security troops (Romania);
- National security corps (Czechoslovakia); and
- Public security guard (Italy, Poland).

In some countries heavy construction work, for railways or roads, as well as purely military purposes, is performed by "construction troops", who may be housed in military barracks, clothed in uniforms, and administered much as a military unit, but are not trained or equipped to fight.

Behind the full-time professional personnel in their armies, navies, and air forces, and also some of the other forces listed above, nearly all countries maintain some form of reserve, usually composed of personnel carrying out civilian jobs, but with some obligation to continue with military training. There is a great variation in the readiness and competence of the reserve personnel, and of the real usable strength that they would represent in the event of full mobilization[18].

Finally, to complicate the problem of categorization even further, all military organizations require considerable support services, but vary in the degree to which they obtain these from civilian employees rather than uniformed military personnel. The proportion would change if a unit were deployed away from a permanent peacetime base into a mobile field formation. In past campaigns some armies have moved with a large train of civilian "camp followers" to provide the support services, and the practice is unlikely to disappear in the future.

This involved problem of categorizing paramilitary organizations will bedevil negotiations for personnel limitations. Once an agreement has been reached, it will present great difficulties for verification, especially in circumstances in which one or more of the participants wishes to deceive the verification process by locating some of its military personnel in units not subject to limitation, or by expanding the functions of paramilitary organizations to conduct training for purely military roles. One has only to remember the experience of the Interallied Control Commissions in this context.

The question as to which organizations needed to be reported was considered in the American submissions to the UN Commission on Disarmament in the 1950s, summarized above. The proposals suggested that

quite detailed information should be given regarding the status, role, personnel and deployment of military and paramilitary units.

Comparison between Verification of Personnel and of Equipment

For those arms control agreements already in place, the most satisfactory and effective verification has been for intercontinental strategic weapons. The reason for this is that the objects for verification are large enough to be easily identified by reconnaissance satellites, and too large to be easily concealed. An underground Intercontinental Ballistic Missile (ICBM) silo takes many months to excavate and fabricate. Although submarines and bomber aircraft are constantly on the move, and can be hidden, they are clearly visible when at their operating bases, which are well known. Individual missiles or bombs are difficult to detect and count, but the number that can be carried by a submarine or an aircraft is limited by the volume and carrying capacity of the vehicle.

Verification of Intermediate Nuclear Forces was more difficult, and necessitated intrusive measures of on-site inspection. However, the objects were large and distinct enough to be identified by inspectors allowed close access to the missiles, although in some cases they required the aid of instruments designed to measure sizes and determine shapes when the missile was inside a container.

Verification of treaty limited equipment (TLE) under the CFE Treaty will be more difficult still, since the objects (tanks, armoured combat vehicles, artillery pieces, aircraft, and helicopters) are more numerous, and exist in many different forms, not always easy to distinguish from non-limited items with the same general appearance.

Verification of personnel poses a number of serious difficulties beyond those encountered with equipment. While it is relatively easy for an inspector to identify a person, and to judge whether this person is likely to be fit for military service, it is quite a different matter to count the total number of persons who are in fact in military service (or available to return to immediately useful military service), in such a way as to be confident that large numbers have not been omitted. Also, in the case of weapon systems it may be possible to verify several of the stages in the cycle of testing, production, deployment, maintenance, withdrawal, and destruction. Parallel processes cannot always be followed for personnel. For example, witnesses can observe the irrevocable physical destruction of missiles or aircraft, but this is hardly possible for demobilized soldiers.

Individually identifiable tags can be permanently attached to pieces of equipment by means that prevent undetected tampering. Equipment can also be

stored in warehouses for long periods, with entry and exit monitored. Key components can be removed from weapons and stored separately. It seems unlikely that any of these actions can be applied to people. Moreover, while the inventory of equipment can remain constant over a considerable period of time, people age, are promoted or moved, and some of them become ill or die; so that the nominal roll of individuals is constantly changing, although the total number in service could be kept at the same level.

IV. Verification Methodologies: A Description and Discussion

Verification by Examination of National Accounts

According to the professed principles of most democratic nations, governments are accountable to their taxpayers for the way in which they spend public money. National accounts should therefore be freely available, and should reveal all of the expenses incurred by the government, both those planned for future years and those already spent. And they should be presented to parliament for public debate and authorization.

National security prevents some of the details of defence expenditures from being elaborated. It would be stated, for example, that a certain number of a particular type of military aircraft are being purchased for a certain sum of money, but many of the characteristics would not be revealed. Or the total budget of a laboratory would be given, but only a general overview of its activities offered. However, some programs (labelled as "black" in the USA) are considered to be too secret to be revealed at all. The funds to support them have to be provided without open public scrutiny.

In some countries, much of the government expenditures never appear in public accounts at all, and the decisions to appropriate the monies are made by a small group of officials not accountable to public scrutiny. For many years the Warsaw Pact countries followed this pattern, publishing national accounts that understated by a huge factor their expenditures for defence.

For most large-scale government-sponsored activities the payroll for personnel constitutes a major element of expenditure. The budgets for personnel in the armed forces can approximate 50 percent of all expenditures when the costs of housing, training, feeding, clothing, transportation and general maintenance are added to basic pay. In a detailed defence budget, truthfully presented, it should not be difficult to verify that the number of military personnel (with published distribution of rank, pay, and allowances) tallies with the stated costs.

As with other forms of verification, the trouble comes in cases where the party under inspection wishes to deceive the verifiers. Many nations do not have the open bookkeeping described above. Even those practising reasonably open bookkeeping have means of concealing expenditures up to a certain level. A famous example is the Manhattan Project for the development of the atomic bomb in World War II, which cost an enormous sum of money but remained unknown to the public until after the war had ended. Other examples are to be

found in intelligence activity, which is funded with a minimum of public knowledge.

The conclusion of the foregoing analysis would be that verification of total military personnel (or of other major defence programs) through analysis of public accounts would provide confirmation only in cases where an open system was in practice. But when the public financial system of the government in question allowed it to conceal the support of major activities, verification through examination of public accounts would be ineffective.

At a much lower level, accounts of expenditures at a military base for items such as food or canteen supplies could provide some evidence as to the number of personnel currently on the base. Possibly one of the rights of an OSI team could be to inspect certain of the base accounts.

The annual exchange of military information recommended in the Vienna Document of the CSCE included declaration of military budgets[19]. The UN has invited countries to use the same "Instrument for Standardized International Reporting of Military Expenditures" since 1985[20]. Such military budget information is at a very high level of generalization and therefore would seem to be of only marginal use for verifying military personnel limitations. However, these measures may provide a useful precedent for more detailed information exchanges.

It is also worth noting that in its papers submitted to the UN Commission on Disarmament in the early 1950s, summarized above, the USA delegation recommended that a number of reports be made available concerning personnel, material, deployment, and activities on military bases, which included budgetary information.

On-site Inspection

The obvious method of verifying the personnel strength of an army is to send inspectors to see and count soldiers. But, until recently, such an action was considered too intrusive to be permitted, and likely to be used for intelligence gathering rather than for arms control verification.

The desire to achieve the INF Treaty, the realization that it would not be accepted without a satisfactory degree of verification, and the judgement that the non-intrusive means such as satellite photography would not be sufficient to verify the absence of mobile intermediate range missiles, all combined to produce an agreement which permitted inspectors to be present for several purposes. These included the witnessing of the destruction of weapons, the confirmation that all weapons had been removed from a particular site, and the

confirmation that there were no forbidden weapons at some location chosen by the inspectors.

The CFE Treaty deals with weapons that are smaller and more mobile than ballistic or cruise missiles, and sets quite high limits on the number of weapons to be allowed, rather than abolishing entire categories completely. These factors pose a more difficult problem for verification. Consequently, an extensive regime of OSI was negotiated.

As was described above, effective verification of personnel presents problems considerably more difficult than the verification of large physical objects. It appears certain that OSI will be required, and that to be effective it may have to be more intrusive than will be experienced under the CFE Treaty.

Some of the elements of OSI considered during the CFE negotiations could be applicable to personnel verification. The inspected country, for example, might declare a number of locations, probably army and air bases, where significant numbers of military personnel of the categories to be limited were stationed. The inspecting organization would be entitled to make an agreed number of inspections at these bases.

The basic OSI would be a routine visit by a team of inspectors to one of these bases. Some visits would be scheduled, with the base and date known to both parties well in advance. But it would be advisable to add an agreed number of inspections at those bases to be made on very short notice.

Another possibility is to have inspectors permanently stationed at a base. They could be given the authority to roam at will, perhaps with access being denied to certain "off limits" buildings or facilities[21].

Or the permanently stationed inspectors could be confined to a portal or gate at the entrance to a base or location within a base. In the MBFR negotiations a similar idea was called an "Entry/Exit Point" (EEP), and in the INF Treaty the process is called "Perimeter and Portal Monitoring" (PPM), in this case monitoring missiles rather than people. For such an approach to be useful, it would be necessary to prevent easy entry or exit via places other than the portal(s). While it might not be necessary to keep inspectors at the EEP continually, especially if tamper-resistant sensors were emplaced there, it is likely that they would have to be there for considerable unbroken periods if they are to collect credible data regarding entry and exit of personnel through their portal.

In addition to the authority to conduct inspections at an agreed set of military bases, confidence in verification would be considerably enhanced by

having the right to demand an agreed number of "challenge" inspections of any other locations, perhaps with some exceptions declared to be "off limits".

A regime of OSI confined to routine scheduled visits to agreed bases without monitored EEP would be extremely vulnerable to evasion. Troops in excess of the number declared, would simply be sent elsewhere before the date of the inspection. Short-notice inspections would make this more difficult for the evaders, especially if the inspecting party had been able to install remote sensing devices operating continually, or from the moment when the inspection was requested, which recorded traffic out of the base. But, especially for personnel, the right to make short-notice inspections at declared sites and at other locations would be very desirable indeed.

A factor of potential importance would be the implementation of verification by a coalition or alliance of countries, certain ones of whom possessed intelligence gathering equipment able to collect information which they were not willing to share (at least completely) with the others. If this capability gave one of them evidence that personnel was being concentrated in one of the bases on the OSI list, or in some other location, they could suggest to a fellow inspecting nation a promising target for a short-notice or challenge inspection, without revealing the source of their information. However, even without the short-notice or challenge inspections being "triggered" by outside intelligence, to have a significant number of them allowed in addition to the routine inspections would make evasion considerably more difficult.

Remote and Short-range Sensors

a) National Technical Means

For most of the arms control treaties in effect today, verification is by or includes "National Technical Means" (NTM). These means include all the technical methods of gathering intelligence which do not require the cooperation of the inspected party. In large measure, NTM of the two superpowers involves imagery and interception of radio transmissions, obtained from satellites orbiting across the territory concerned. The use of NTM has been reinforced to the extent that recent treaties include agreement not to interfere with NTM.

NTM can be supplemented by other unilateral methods. These include the activities of diplomats, military attachés, and analysts of publicly available newspapers and journals, and the interviewing of returning travellers. NTM and such additional methods are sometimes subsumed under the heading "National Intelligence Means".

b) Satellite-borne Sensors[22]

The resolution obtainable from a military surveillance satellite orbiting at approximately 200 km above its targets is now quite sufficient to provide excellent photographic images of large objects (such as ICBM sites, ships, and buildings). They can also detect smaller objects (such as tanks and other vehicles, guns, and aircraft on the ground), although the resolution is generally less than ideally suited for precise recognition, identification, and description. Multispectral sensors able to produce images from infrared as well as visible radiation increase the capability to distinguish targets from the background. Sensors depending on radiation in the radar rather than the optical or infrared frequency bands have the important advantage of being able to operate at night or through clouds, but cannot achieve the fine resolution of the optical sensors.

Technology is constantly improving the resolution of both optical and radar sensors, with the two superpowers being several years ahead of the rest of the world. Today it is probable that the most advanced optical surveillance satellites are able to distinguish objects as small as a person, but that this resolution cannot yet be attained with radar. Not even the best surveillance satellites of the non-superpowers are able to distinguish an object as small as a person.

Thus today's technology presents the combination of an extraordinary capability of a satellite to cover the earth, with a limited capability of its sensors to achieve the resolution necessary to distinguish a person from high altitude.

In the context of verification of personnel, monitoring by satellite may be able to provide extensive information regarding large and observable objects that will assist in estimating the number of (directly unobservable) personnel associated with these observable objects. Perhaps there is a parallel with the problems of atomic physics which has managed to deduce a great deal of information about the structure of atoms, but without ever being able to actually "see" anything as small as a single atom.

c) Airborne Sensors[23]

At the altitude commonly flown by aircraft, photography can provide the resolution necessary to detect individual persons, and the electrical power can be made available for an extremely sophisticated radar. But unless it is possible to fly over the territory to be investigated, only the area close to the border can be observed, and then at very oblique angles, so that the utility for verification of personnel would be very limited.

Figure 1: A Layered Approach to Verifying Military Personnel

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Satellite (NTM)	160 – 1000 km	15 cm (NTM) – 8 m (Commercial)	• Facilities • Equipment	High
Aircraft	< .5 km – > 50 km	< 1 m	• Facilities • Equipment • Military Parades	Moderate
On-site Inspection (OSI)	< 1 m – > 1 km	< 1 m	• Personnel • Equipment • Facilities	Moderate
Perimeter and Portal Monitoring (PPM)	1 — 10 m	—	• Personnel • Equipment	Moderate
Records Monitoring	—	—	• Personnel	Moderate
Identity Cards	< 1 m	—	• Personnel	Moderate to Low
Data Exchange	—	—	• Personnel • Unit • Equipment • Facilities	Low

If direct overflight of the territory is permitted by the agreement, photography with detail sufficient to show individuals should be easy. There is no doubt that the addition of radar (preferably sideways-looking, synthetic aperture, or pulse-doppler), electro-optical detectors, thermal infrared sensors, multispectral scanners and signals receivers would add a great deal to the amount of information obtained in an overflight, but most of this would not be as directly applicable to the verification of a personnel agreement as it would be to the collection of general intelligence, which is not the purpose of verification.

d) Short-range Sensors[24]

Satellites are not intrusive, and aircraft not very intrusive. In contrast, inspectors on the ground are intrusive, potentially very intrusive. To minimize this objectionable aspect of verification, it may be desirable to use unmanned sensing devices on the ground to accomplish as many verification tasks as possible, and keep the number of human inspectors to as few as is absolutely necessary. Further advantages of automatic sensing devices are that they do not suffer from the human tendency to boredom and inattention, and they cannot look for or acquire information for which they are not designed. A danger is that the inspected party may be able to deactivate them while he conducts some activity which he wishes to conceal from detection. However, the development of *in situ* sensors for verification of the Non-proliferation and the INF Treaties has shown how to make them practically "tamper-proof", so that such interference should be detected by the inspectors.

One function for which unmanned ground sensors could be very useful in the context of verification of personnel limits is the establishment of a boundary around a military base that is intended to channel all entries and exits through EEP at which some sort of inspection could be exercised. Instead of (or as well as) erecting a fence which would provide a physical obstacle to crossing, a line of sensors would give an alarm whenever a person entered the strip defining the boundary. For the detection of human presence and movement, several phenomena can be used to activate a sensor. These include sound (transmitted through the air or the ground), pressure on the ground, or interruption of an infrared light, or microwave beam. Television can transmit to a central site a picture of activity obtained in the visible or infrared wavebands. Touching of trip wires can activate an alarm.

One potential difficulty with the use of short-range sensors for verifying personnel is their cost. If such devices were to be permanently deployed at a large number of military bases, the level of effort and the cost involved would likely be considerable. If, however, such devices were deployed more discriminately, perhaps on a temporary basis during an OSI of a base, costs might be significantly less.

Figure 2. Base Infrastructure as a Means of Verifying Military Personnel

Canada's Verification Research Program has done some preliminary research into the use of portable tamper-resistant unattended sensor stations for monitoring vehicular traffic at facility portals and transportation chokepoints. The results of this research indicate that, for moderate costs and using off-the-shelf unclassified technology, such stations could be developed. The stations would be modular in make-up, deployable by two trained personnel within less than an hour and operate unattended for periods of 20 to 40 days.

Detection and counting of the passage of vehicles along a road, or across a bridge, could be useful as an adjunct to an OSI in which there was reason to suspect that troops were being moved in order to evade inspection. The takeoffs and landings of aircraft can be recorded. These, however, are easier technical problems than is the detection and counting of people.

The Numerical Relationship between Personnel and Equipment

The easiest things to observe, identify, itemize, count, and verify are large unmistakable objects, such as fixed ICBM, warships, tanks, other military combat vehicles, guns, aircraft, and helicopters. This (plus their obvious importance for aggressive offensive employment) is why they were selected as the objects to be limited in Strategic Arms Limitation Treaty (SALT), INF, CFE, and START.

In contrast, personnel is going to be much more difficult to verify. It could be argued that personnel matters much less than weapons as a measure of combat capability, and therefore need not be subject to limitation if the weapons are effectively under control.

This point of view has considerable validity for strategic weapon systems such as ballistic missiles, and for navies and air forces. Here the effective unit of combat power is the missile, the warship, and the aircraft. (A better measure would be the number of warheads, but this is too difficult to verify directly.) Presumably the owners of these expensive systems will see that the number of personnel necessary to employ the weapons to their full effectiveness is made available. Adding further personnel beyond this level would make little difference unless additional weapons were also added. Agreements purporting to limit combat power of strategic forces or of general-purpose naval and air forces[25] may therefore never set limits on personnel, but concentrate instead on the more significant and more verifiable number of major weapon systems.

When we come to armies, the situation is different. To be effective on a modern battlefield, armies need major weapons such as combat vehicles and artillery, as well as the support of aircraft and helicopters. However, soldiers can fight as infantry, using weapons such as mortars, machine guns, rifles, grenades, and bayonets, weapons which would be even more difficult to verify than personnel. The movement of personnel and light weapons can be expedited by transport aircraft and trucks, which can be interchangeable with civilian vehicles.

Spurred by the development of the tank, but also exploiting the constantly improving capabilities of other combat vehicles, of artillery, of communications, and of various forms of air support, modern armies have developed formations able to combine the advantages of all the various arms. Typically, the basic major formations of large armies will be two kinds of divisions, one commonly labelled as "armoured", and the other as "infantry". Both have considerable numbers of tanks, other combat vehicles, and artillery, but the "armoured" division has a greater ratio of tanks to infantry, and is more mobile[26]. Inside the divisions are sub-units commonly described as "brigades", or "regiments", which are in turn divided into smaller sub-units (in the case of infantry: "battalions"). An army corps will have two or more divisions in addition to "corps troops" to provide extra firepower and other support for the divisions. These corps troops will not

be organized into standard armoured or mechanized divisions, but will have specialized roles such as airborne assault, artillery or engineering support.

If the detailed inventory of equipment and personnel, commonly designated as a "Table of Organization and Equipment" (TOE) of the army, were precisely known to the verifying organization, and it was able to count the combat vehicles, artillery, helicopters, or other easily identifiable weapons in a particular unit, it could deduce the unit's personnel from the TOE, assuming the unit to be at 100 percent strength in both equipment and personnel. In an atmosphere of perfect trust, in which the inspected army had provided an accurate report of the organizations being inspected, this method would produce verification of personnel that was as precise as that for the equipment. However, if the information regarding the TOE was inaccurate, or if the manning of the units did not match the announced TOE, then by using this method the inspectors would not arrive at an accurate estimate of the personnel. Developing "orders of battle" of enemy forces (potential or actual) by military intelligence organizations follows an analogous process, though with considerably less information volunteered by the other side.

Table 2 shows the number of main battle tanks, armoured combat vehicles, artillery pieces, and personnel in the armoured and infantry divisions of six countries with large armies[27].

One feature immediately evident from Table 2 is the notable differences among the designs of the divisions, both between armoured and infantry divisions and among countries. For example, both types of German divisions have over 21,000 soldiers, the French divisions less than 10,000. The American and German infantry divisions have more than 250 tanks, while the French and British have none at all. There is a distinct difference in the numbers of soldiers per ACV: about 30 for both types of Soviet and French division, but over 100 for the Germans, while the Chinese have no ACV at all. The Soviets have an artillery piece for every 65 soldiers, while the ratio of personnel to guns is over 130 for all the other divisions.

Clearly, any system of verification depending on accurate declarations would need separate TOE pertaining to each army and each type of division. If surveillance and inspection can estimate the number of tanks, guns, or some other type of observable and countable weapons, but not the number of personnel, and find the count of weapons in acceptable agreement with the TOE for the type of division in question, it could be inferred that the personnel strength also matches the TOE. However, it is obviously possible for the division to have additional personnel without increasing the number of observable and countable weapons. The question is whether the extra personnel will add significantly to the combat capability of the reinforced division. Presumably the

TOE was designed for optimum matching of weapons with personnel for certain roles for the division. Would the additional personnel be of little use, or would it permit the reinforced division to extend its capability, perhaps for different roles?

Table 2.

Numbers of Weapons and Personnel in Armoured and Infantry Divisions of Six Countries

		Numbers				Ratio of Personnel to TLE		
Country	Formation	MBT	ACV	ARTY	Personnel	MBT	ACV	ARTY
USA	Armoured Div	348	240	111	16,800	48	70	151
	Mechanized Div	290	300	75	17,100	59	57	228
USSR	Tank Div	319	347	162	11,100	35	32	69
	Motorized Rifle Div	213	547	204	13,500	63	25	66
China	Armoured Div	323	0	32	9,900	31	—	309
	Infy. Div	80	0	60	13,400	168	—	223
UK	Armoured Div	285	415	72	14,900	52	36	207
	Infy. Div	0	129	54	14,000	—	109	259
Germany	Armoured Div	308	164	158	21,250	69	130	134
	Armd. Infy. Div	252	190	164	21,500	85	113	131
France	Armoured Div	190	254	68	9,000	47	35	132
	Motorized Infy. Div	0	270	42	7,200	—	27	171

Source: Data from International Institute for Strategic Studies, *The Military Balance, 1987-1988* (London: IISS, 1987).

To take an example, suppose that information resulting from the surveillance and inspection of a Soviet tank division was consistent with the TOE of 319 tanks. It might then be inferred that the personnel strength was probably close to the 11,100 figure of the TOE (representing a personnel-to-tanks ratio of 35). But it would have been possible to add another 9,000 persons to the division (thus raising the ratio of personnel-to-tanks to 63) without exceeding the ratio of personnel-to-tanks of a Soviet motorized rifle division. However, the addition of 9,000 soldiers would change the ratio of personnel-to-ACV from 32 to 58, and the ratio of personnel-to-guns from 69 to 124, both much higher than the ratios for a Soviet motorized rifle division. Presumably the altered balance of personnel to equipment would be unsuitable for efficient infantry operations, unless more ACV and guns were added too. Such additions could be detected if the verification regime included ACV and guns as well as tanks. This illustrates the value for verification of combining several items of information rather than relying on only one.

The addition of 3750 soldiers to a British armoured division would give it an ACV for every 44 persons (over twice the ratio of mechanization accepted for a British infantry division), and 256 persons for every gun, the same as for a British infantry division. In this case an addition to infantry strength could be made without an increase in verifiable weapons of the three types considered.

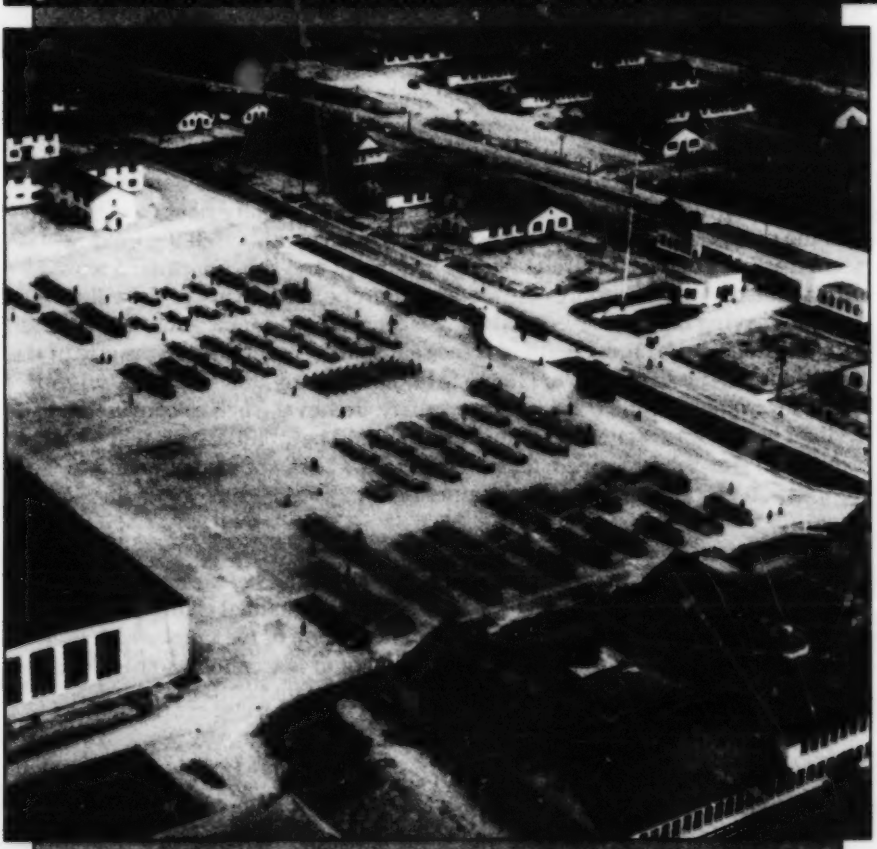
NTM may be able to provide some information regarding personnel strength, since formations on parade may be visible in overhead photography and relevant data may be picked up from signals intelligence. If aerial inspection were permitted, or an Open Skies regime, there would be opportunities to make sample counts of personnel. NTM, aerial and OSI will allow buildings, exercise areas, vehicle parks, and other facilities associated with military personnel to be observed from the outside. Agreement might be reached to permit inspectors to enter them during an OSI. Some practical correlation must exist between the volume of barracks and mess halls, or the number of military pattern vehicles, and the number of troops which they are able to serve, although it would not seem feasible to specify the relationship in a treaty, and the proportions would differ from country to country. However, in Europe, with many of the military facilities having been constructed during wartime, or in preparation for wartime mobilization, and having regard to recent substantial reductions in the size of the armed forces, these facilities are likely to be significantly underutilized, serving far fewer troops than their maximum capacity. Removal (such as conversion to civilian use) or destruction of some of them would be an indication that no large expansion was being planned, and could perhaps be negotiated as an aid to verification and an obstacle to rearmament.

If the inspectors selected for OSI duty are experienced military officers and have some familiarity with the normal life and habits of the army which they are inspecting, they should be able to sense a substantial change, or discrepancy, from the "normal" pattern of organization of the units which they are visiting, especially if they have had the benefit of inspecting some other units with the same stated TOE, or if they have been associated with the unit as a permanent inspector.

If deception is practised with the TOE, it could be done by insertion of extra personnel in the form of additional complete sub-units (platoons, companies, battalions) introduced into existing (larger) formations, or perhaps corps troops. Another method would be to make a general strengthening of the personnel of units already in the "order of battle". In the former case, evidence could appear in the form of unit badges, markings of vehicles, or housing or messing arrangements. In the latter, witness to a parade, or exercise, could reveal the presence of additional personnel. Such parades could be notified in advance to facilitate observation. In either case, the presence of an unusual number of weapons or equipment not limited by treaty might be noticed.

While the revelation of a full and truthful TOE would have been considered as a serious breach of security a few years ago in many countries, it does not seem as revolutionary today. As summarized above, proposals were submitted in the early 1950s by the USA delegation to the UN Commission on Disarmament for reports to be given on deployment, bases, and facilities.

Figure 3. Prior Notification and Observation of Military Parades



Similar, though less detailed, measures were incorporated into the Vienna Document of 1990.

This relationship between the weapons inventory of a "standard combat formation" and the personnel operating them will have little relevance to irregular or less technologically advanced armies with simple weapons and variable organizations.

The Identification of Personnel

a) The Usefulness of Tagging for the Verification of Weapons

For an agreement which permits a limited number of a particular type of mobile weapons to be deployed (perhaps within a designated region), verification can be greatly aided if it is possible to identify each weapon individually. This can be even more effective if information is provided regarding the detailed deployment of these weapons, with the identity and location of all permitted weapons being listed. When this is done, the legitimacy of any observed weapon can be checked against the declared list.

For example, if 50 heavy bombers were permitted, and each had a unique tail number, discovery of an aircraft appearing to be a heavy bomber, but not carrying one of the announced tail numbers, would indicate a violation. But it would be possible for the same tail number to be painted on more than one bomber. To recognize such a violation, it would be necessary to observe two bombers with the same number at the same time, or at least nearly enough the same time that it would not have been possible for the same aircraft to have been observed on both occasions. If tail numbers could be identified by overhead surveillance, the possibility of nearly simultaneous observation of two bombers with the same number but at different locations would always exist, unless considerable care were taken to only expose one at a time. It would, for example, be risky for the evaders to involve more that 50 bombers in a single exercise.

If identification were only possible by OSI, bombers on a base about to be inspected could dispatch any with duplicate numbers away before the inspectors arrived. The need to do this could be avoided by never allowing two with the same number to be present on the same base at any time (thus limiting the number ever present on one base to a maximum of 50). The contest between inspector and evader could be complicated further if simultaneous OSI were permitted, but the evader could always succeed, at the cost of rapid departure of bombers with duplicate numbers, unless yet a further complication were introduced to prevent departure of aircraft during the interval between announcement of an OSI and the arrival of the inspecting team.

Evasion of verification efforts becomes more difficult if the objects are less mobile than bombers, but easier if it is possible to hide the objects from OSI rather than having to remove them from the site.

Verification would be aided if each object were obliged to remain on one of the bases (or sub-areas) at which an OSI was permitted (or only allowed to move elsewhere on exceptional occasions requiring notification). In this case, all objects with duplicate numbers would be identified as violators if observed at a base other than the one registered, and, if observed while at the registered base,

would run the risk of having their duplicate with the same number observed during the same OSI.

It would, of course, be a simple matter for tail numbers (or the numerical labels on missiles or vehicles) to be repainted, although perhaps not undetectably on very short notice. To defeat this possibility, "tags" which have been designed to be affixed in such a way that they cannot be removed without the evidence of removal being easily detected, might be employed. A further advantage of tags is that they can be made unique and non-reproducible. This would allow every permitted object to have its own tag without which it would be in violation of the treaty. Identification of the tags will require an instrument, used at close quarters by inspectors during an OSI. But it may also be possible to devise electronic tags that can be interrogated at a distance, thus enabling a moving object to be tracked and identified. This last possibility has the objection that the tagged object would be rendered vulnerable to a surprise attack. (Presumably after the surprise had worn off the owners of the surviving objects would disable the tags.)

Even if they cannot be interrogated at a distance, non-reproducible non-removable tamper-proof tags will be a source of great assistance to verification of TLE by OSI, including EEP and PPM stations. It is relevant to discuss the possibility of applying some such technique to the verification of personnel.

b) The Identification of Persons

As compared to combat vehicles, service personnel are small, mobile, easily concealed, and very difficult to distinguish from allowed look-alikes. However, the possibility of individual identification exists, and should be discussed further.

Much of the technology of police work is centred on the identification of individuals who may not wish to cooperate. Two of the most useful techniques are photography and fingerprinting. Identity cards (ID Cards) serving for control of access to sensitive premises usually carry a number, a photo, and often a thumb print. The card may have magnetic imprints to allow automatic readout, and safeguards to prevent tampering or forgery, but its match to a particular individual is made by the photo and thumbprint. Other possible identifiers include body dimensions, dental charts, blood type, microscopic examination of cells for genetic characteristics, hair, eye and skin colouring, and complexion. Using such identifiers, Interpol has had great success in identifying criminals far from their countries of origin.

On the other hand, passport identifications are notoriously easy to counterfeit, at least to the degree needed to deceive the rather perfunctory examination carried out at border immigration points. No aggressive intelligence service or terrorist organization is without its experts able to produce false identification papers. And when time and money are available, plastic and dental surgery and hair implants can be used to alter many of the characteristics normally used for identification. However, in many cases of intentional falsification, the objective is to have the carrier of the passport be accepted as anyone *other* than the person he really is, i.e. *not* to be matched with a wanted illegal. But for the verification of military personnel, the objective of the would-be circumventor is to have him mistakenly matched with someone who he is not, i.e. positively matched with a person legally entitled to be at the base, which is a more difficult requirement.

One measure used centuries ago to identify convicted criminals was to brand them. Another more recent measure was implanting a tattooed number under the skin of prisoners in concentration camps. Of course some individuals voluntarily (and perhaps with the anaesthetic aid of alcohol) have themselves tattooed with a symbol, or motto, which serves as a subsequent lifetime identifier. And a system of remote tracking of individuals on parole, or of persons with certain medical problems, is being developed, by which an implanted or otherwise attached electronic device acts as a "beacon" when interrogated by a transmitter in the possession of the organization wishing to keep track of their whereabouts. However, there is much dislike of such intrusive methods, considered by many to be unreasonable invasions of human privacy. Even the issuance and public use of a Social Security Identification Number has raised considerable indignation.

The problem facing verification of military personnel is that of rapid identification of a large number of individuals. Some mistakes could be tolerated, and it would probably not be acceptable to require a very time-consuming examination of each person, or to subject him to overly intrusive or degrading measures. The examination during an OSI would probably be more akin to that at a border immigration point than in an intensive police investigation. However, it is possible that a more thorough examination of large numbers of fingerprints or photographs could be conducted later, at a central office, with the aid of computer pattern recognition techniques.

Fingerprints would seem to offer one possibility, to be inspected at EEP adjacent to military bases, or in the course of OSI, for subsequent comparison with a previously filed nominal role of all personnel entitled to be on the base. Perhaps it would not be a serious inconvenience for persons entering or leaving a military camp to present their ID Card to an inspector at an EEP, and to have their thumbprint taken. The inspector would compare the photograph on their

ID Card with the person's face, record the name and card number, and transmit the information, with a copy of the thumbprint, by electronic means to a centre at which there was a data bank with the names, card numbers, photographs, and fingerprints of all of the declared members of the military forces, and also of civilians of military age, stationed at the base in question.

Modern methods of data processing and pattern recognition would make it possible to make a rapid and reliable comparison between the thumbprint obtained at the gate and the print filed under the same name.

Fingerprint identification could also be used during an OSI. Personnel on the base with a card would have their photo examined and their thumbprint taken and transmitted to the centre for comparison with the record. As at an EEP, discovery of anyone without an ID Card would constitute a violation. But the weakness of this method would be that personnel not registered for the base could simply not present themselves for examination at an OSI. Unless the inspection were undertaken with complete surprise, and by a very large and knowledgeable team, it is difficult to imagine that large numbers of personnel could not be kept away from the inspecting team.

For identification at an EEP, it would be hoped that all or at least nearly all entries and exits would have to be made through the EEP. While this may be an acceptable assumption for heavy weapon systems such as artillery or large missiles, especially at the entrance to a factory or depot, or in terrain with a limited number of roads, it does not seem very convincing as regards aircraft or people. But the presence of a system such as the one described would put the inspected party to some trouble to circumvent, especially with large numbers of personnel.

The administrative load of such a system however, would be far from negligible for the inspected as well as the inspecting party. All recruits and civilian employees stationed at military bases would have to be provided with ID Cards, carrying a photo and thumbprint. The verification authority would have to be informed of the unit to which they belonged and its location. Unless numbers were falling well below the allowed limits, separations from the military would also have to be notified. Transfers from one base to another would have to be reported in a timely fashion, and it would probably be well to record promotions. Lost identification documents would have to be replaced. Of course, there would be plenty of failures to comply, but if there were a satisfactory explanation, a certain level of non-compliance could be tolerated. And, for the inspecting organization, while an enormous number of prints would have to be stored, the problem of certifying agreement between two which are claimed to be the same is far less time-consuming than the search for a match when there is no clue, such as an individual identification number. Also, the

problem is easier than that faced by the police when all the evidence they have is an imperfect or partial finger print, since both prints in the hands of the verifiers should be of good quality and therefore quickly and reliably compared using modern electro-optical devices.

c) A "MILPER" Card?

In the discussions surrounding the preparation of the final report on this research project, another idea involving a form of "tagging" of military personnel was suggested as a potentially viable verification approach[28]. In this approach, a relatively simple scheme could be designed for providing all military personnel in Europe with a special magnetic card, much like credit cards or those used for automatic banking machines. Each country participating in the system would be given a certain number of cards corresponding to the number of military personnel to which that country was entitled under international agreement plus a certain percentage to account for personnel turnover, loss of cards, etc. Basic information could be magnetically inscribed on the card such as a card sequence number, the soldier's name, his rank and his serial number. All personnel subject to limitation would be required to carry such a military personnel identification or "MILPER" card. The verification related data for each card would be recorded in the central database of an international inspectorate and periodically updated. Under this scheme, on-site inspectors would be equipped with hand-held magnetic card readers and would be entitled to scan the card of any military personnel they encounter.

The system would stand solely on the correspondence of a unique number to a specific individual. A nation with a permitted military personnel level of 100,000, for example, and an annual turnover of 15 percent could be issued between 125,000 to 150,000 MILPER numbers out of a total of, say, 4,000,000 for all of the ATTU. On any given day a significant percentage of military personnel are away from their regular unit. But within the 100,000 ceiling it would not be material where they are, so long as the inspector's card reading machine found a valid number. The inspector would then be presented with a name and rough physical description. Duplicate numbers, invalid numbers, number-to-name-to-description mismatches, and damage/tampering would all invite the inspector's interest.

A retired soldier's number would lie fallow for long enough to remove the chance of system-derived errors. Countries could add all the information they wished to the card, encoding it if they wished, to the point where the card might be the sole document carried by a soldier: his combined paybook, dog tag, medical record, etc.

Countries might also wish to lengthen the number, provided they did it in some standard way, to capture some of the unique national things Canada captures with our Social Insurance Number. So long as the first (or last) seven digits were reserved to the treaty verification purpose, such extensions would be harmless, and so long as the extensions, and any other (encrypted?) personal data could be bit-copied by the inspector's machines, they would have no impact on the confidence building aspect of the system.

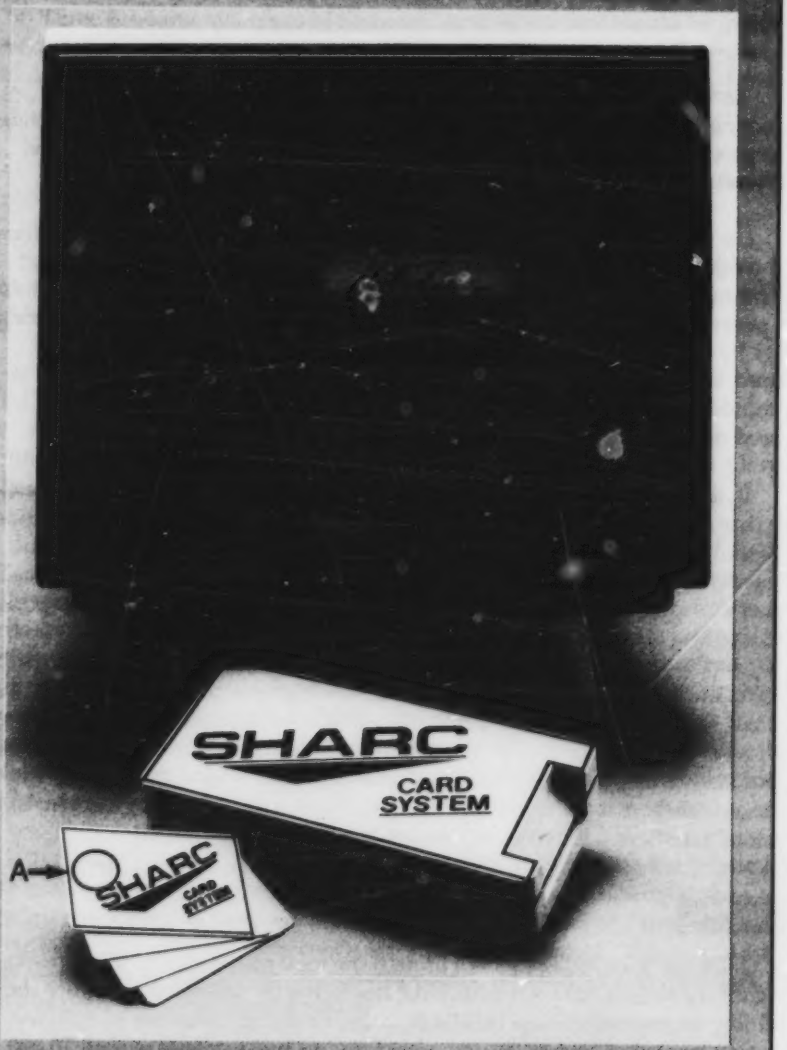
Such a scheme seems technically feasible; credit card companies have much more complicated and universal operations. Costs are very difficult to estimate, but the order of magnitude would likely be in the tens of millions rather than hundreds of millions of dollars.

One advantage for such a system would be its potential as a confidence building measure in addition to its utility as a personnel verification method.

Another recent innovative technology known as "smart cards" may also have relevance to the MILPER card idea[29]. Smart cards are now being considered by many financial, health and security institutions for better automatic control of human resources. The technology is now used in Europe (mainly France) for banking applications. Smart cards are very similar in appearance to the standard credit card, except they have a miniature microprocessor embedded into the card. It is this memory capacity of the smart card that really distinguishes it from other existing forms of cards. The smart card can store up to eight kilobytes of information, including photographs of individuals, their signature, and fingerprints. The time required to input this data is minimal, being very similar to the familiar photo booths that take black and white photographs. The life expectancy of the smart card is twice that of the standard magnetic strip card. The cost of the individual smart cards depends on the volume required, however estimates of $8 to $10 per card seem realistic. The card readers cost approximately $500 each. Presently, portable card readers are being developed which would make the verification of the information contained within a smart card much more of an "on-site" possibility.

Besides verification, armed forces might find this type of card to be a valuable addition to personnel management in future years — a sort of smart "dog tag".

Figure 4. "Smart" Cards



Smaller in appearance to credit cards, smart cards contain a microprocessor (A) with sufficient memory to be able to store considerable information, including photograph, signature and fingerprints of the holder, as well as identification number, rank and other personal data. (Photo courtesy Verification Technologies Incorporated, Mahwah N.Y. USA.)

V. The Relationship between Verification and the Degree of Information Declared

The ability of a verification regime to confirm that parties are complying with an agreement, or are breaking it (such as by conducting redeployments in preparation for an attack), is very much dependent on the precise details of the data that has been provided regarding the stated deployment of treaty-limited items.

Let us assume that verification must be limited to sampling of a relatively small proportion of the total inventory of personnel (or equipment), and that verification consists of making some sort of comparison between data that has been provided regarding the inventory with what is observed by NTM, during OSI, or by any other means. The more detailed and disaggregated the data declared, the more likely it will be that verification limited to sampling will be able to make a reliable estimate as to whether observation tallies with the declared data.

If all that was declared was a single overall total number of troops, and no more than a few small sample observations could be made, then the estimation of the actual number would be very imprecise, and recognition of a breakout necessarily delayed. However, if the inventories are declared for a considerable number of different locations, and divided into a number of different categories, then sampling is far more likely to discover illicit redeployments or discrepancies. If there are a number of discrepancies, and most of them are in the direction indicating that the actual numbers are higher than those declared, then there is a correspondingly high probability that the true total is more than the number declared. If, on the other hand, a series of sample observations does *not* discover evidence of redeployments or serious discrepancies, the confidence increases that there is no significant redeployment, and that the agreement to keep total numbers within the negotiated level is being honoured.

Examples

Suppose that the agreement limited the total number of military personnel for a country to 1,000,000. An additional limitation [F], intended to reduce the possibility of successful surprise attack, could be that the number of military personnel located at each of the ten most forward bases cannot exceed 10,000.

Let us assume that surveillance (by NTM, plus whatever other means are agreed), supplemented by challenge OSI at non-declared sites, will be able to discover the existence of non-declared troop concentrations, but that

identification of units and of individuals will only be possible through OSI at declared locations.

Three fundamental types of declared information that would be important for verification would be:

[L] the locations in which military formations were concentrated;

[U] the units into which the armed forces were organized; and

[I] the names (and other information related to personal identification) of the individual members of the armed forces.

It is instructive to examine the significance for verification of various combinations of these three basic types of information. There are eight possible combinations, summarized in Table 3.

If the only declaration is that the total military personnel does not exceed 1,000,000, which is condition [D_0], then it would not be possible for OSI to prove that the limit had been exceeded. In the case [F] (limiting the number of personnel at any forward base to 10,000), an OSI might be able to detect a large excess.

Suppose that the inspected party increases the total number of soldiers well above 1,000,000. With no declared data (condition [D_0], or none other than the location of the bases (condition [D_1]), a succession of sample inspections at a few bases may cause the inspectors to begin to suspect that numbers are rising, but they will certainly never see 1,000,000 persons in a short space of time. For all they know, the increased numbers at the bases inspected may have come from reductions at other bases not inspected. However, if the inspectors visit the forward bases there will be a good probability that they will detect evidence of forward redeployment (an action presumably not forbidden, but nevertheless a possible sign of coming trouble).

If the limitation [F] on the forward bases had been agreed, the inspectors could concentrate their inspections on the forward bases, and increase the statistical confidence in their estimates of the numbers deployed forward. But to be able to declare with certainty that a violation had occurred, they would have to see more than 10,000 persons in one inspection, which might be rendered highly improbable by evasive measures.

Declaration of locations (cases [D_1], [D_3], [D_6], and [D_7]) will deter the creation of new (undeclared) concentrations, since these will be detected by surveillance.

Table 3:

The Relationship between Verification and the Degree of Information Declared

Option & Unit	Declaration	Type of Deployment Detected
[D_0] – – –	Nothing declared	
[D_1] L – –	Locations at which forces are stationed and OSI permitted	Creation of new bases
[D_2] – U –	Units into which defence forces are organized	Creation of new units on declared bases
[D_3] L U –	Both units and their locations	Creation or redeployment of units
[D_4] – – I	Nominal roll of personnel	Additional personnel on declared bases
[D_5] – U I	Units with their nominal rolls	Creation or expansion of units
[D_6] L – I	Nominal roll, with locations	Redeployment of expansion of personnel on declared bases
[D_7] L U I	Nominal roll, units, and their locations	Creation, expansion or redeployment of units: expansion or redeployment of personnel

L = Location U = Unit I = Individual Identification

Declaration of units [D_2] would inhibit the inspected party from attempting the undetected deployment of new units (assuming that units can be identified by the inspectors). They could, however, expand the size of the declared units and deploy elements of the same unit to more than one base, building the total personnel beyond 1,000,000. Inspectors would probably acquire evidence of this, but would have great difficulty in observing more than the declared numbers on any one occasion.

Declaration of units together with their location [D_3] would inhibit the inspected party from deploying new units anywhere, or from adding new components of declared units at additional bases. Expansion of a declared unit far beyond the declared strength on one base would make detection of the violation more likely. If the forward limitation [F] were in effect, provision [D_3] would inhibit the inspected party from deploying additional units into the forward bases.

Some form of individual identification [D_4], such as ID Cards for each soldier, with copies and a nominal roll for the inspecting agency, would aid in detecting redeployment of the permitted 1,000,000 soldiers, and should increase the general amount of intelligence being accumulated regarding movements and activities. It would mean that soldiers in excess of the permitted 1,000,000 had no declared ID Cards, or used duplicates of cards carried by others previously declared. Such non-compliance would probably be discovered in an OSI.

Nominal rolls of units without locations [D_5] would inhibit the creation of new units, or the addition of personnel to units above their declared strength. The inspectors would soon learn of the locations of the units, and would be able to detect redeployments, although these would not constitute violations of the agreement. If the allocation of major armaments of each unit were included as well as the personnel, then the opportunities for personnel verification by use of TOE discussed above would be obtained.

Specification of the location of each individual [D_6] would inhibit expansion of personnel and redeployment among bases, but would allow reorganization of units within a base. It would expose violation of the [F] provision to discovery.

Finally, if all three items (individual identity, unit, and location) were declared [D_7], it would be quite difficult for the inspected party to create new units, add many personnel to a base or to a unit, or to carry out a substantial redeployment, without exposing himself to detection.

Suppose that a significant number of personnel are moved from the rear areas into the 10 forward bases, increasing their strengths above 10,000 each. If all the verifiers can do is to try to count personnel, sample counting on OSI will not likely allow them to see more than 10,000 persons at any base within any short period, although they may become suspicious that the numbers are greater than estimated at a previous inspection. If the extra personnel entered a base through a constantly operating EEP, they ought to be detected, although this should not be difficult to circumvent on a special occasion, possibly by use of helicopters or an overland night march. Alternatively, the extra personnel could be infiltrated into locations in the forward area not on declared bases, in which case there would be no EEP, only the right of a challenge inspection, presumably triggered by collateral intelligence indicating the presence of a new military activity. (Here we are assuming a verification regime like that of the CFE Treaty.)

In the cases of both locations and units, the more disaggregated the declarations the better will be the verification. A useful breakdown of locations could be by military bases, since these have probably been formed for specific roles, cover limited areas, and would be natural locations for OSI. Under the Vienna Document, the normal peacetime location of each formation and combat unit is to be provided using exact geographic terms and/or coordinates. Under the CFE Treaty, the designation and peacetime location of formations and units containing TLE are to be provided specifying the geographic name and coordinates.

Subdivisions below base level could create problems if the rights for OSI were also divided up by corresponding subdivisions, since, for example,

personnel could be very quickly moved from a subdivision of a base selected for a surprise inspection to another part of the same base not being inspected. In the case of units, a governing factor is the confidence with which an inspector will be able to identify the unit to which a soldier belongs.

If the trade specialty of each serviceman were specified, and the inspecting organization was able to identify certain key trades whose activity gave a special clue as to the growth or redeployment of important capabilities, movement of members of these trades could provide evidence of build-ups.

The process of combining various items of incomplete information to deduce the state of a foreign military organization is very much the function of the intelligence services. Therefore, although the verification process is not supposed to serve as a source of intelligence, the process of evaluating the information achieved through verification is likely to make use of information acquired from various sources of intelligence. Not surprisingly there is a conflict between the desire to obtain reliable verification and the desire to deny a potential enemy knowledge of one's own capabilities.

TOE to Be Declared

If it is agreed that information regarding the composition of military units is to be declared, the question must be answered as to exactly what units they will be, and the detail that must be described.

It would, in principle, be possible to draw the agreement regarding personnel (and perhaps weapons) limitations in terms of units (divisions, brigades, battalions, air squadrons). If this were done, these would obviously be the units whose TOE should be declared. However, if the limitation is to be personnel, and there is to be valuable assistance to verification to be gained from declaring TOE, it is not immediately obvious what is the most useful level of military organization to form the basis of data exchange, or what type of weapons and equipment should be declared. Brigades or battalions have been suggested for infantry formations. It would be necessary to specify corresponding units for armoured and artillery formations, for fixed-wing and helicopter units, and probably other important organizations including some for combat support[30].

A relevant consideration would be the size of formation which could be given a reasonably thorough inspection in a single visit conducted within the limitations of the OSI agreement. If, for example, an OSI team could make a good estimate of the personnel of a battalion from one visit, but no more than a very imprecise assessment of a brigade, it would be better to have the accounting based on battalions. The judgement would have to take into account the size of

the inspection teams, the time they could spend on site, and the facilities open to them.

Another consideration would be the sizes of the formations at the locations for which OSI were authorized. If many declared bases had divisions or corps on the premises, then the most satisfactory verification would probably require the provision of TOE and sampling capabilities of single OSI to be for divisions or brigades rather than battalions.

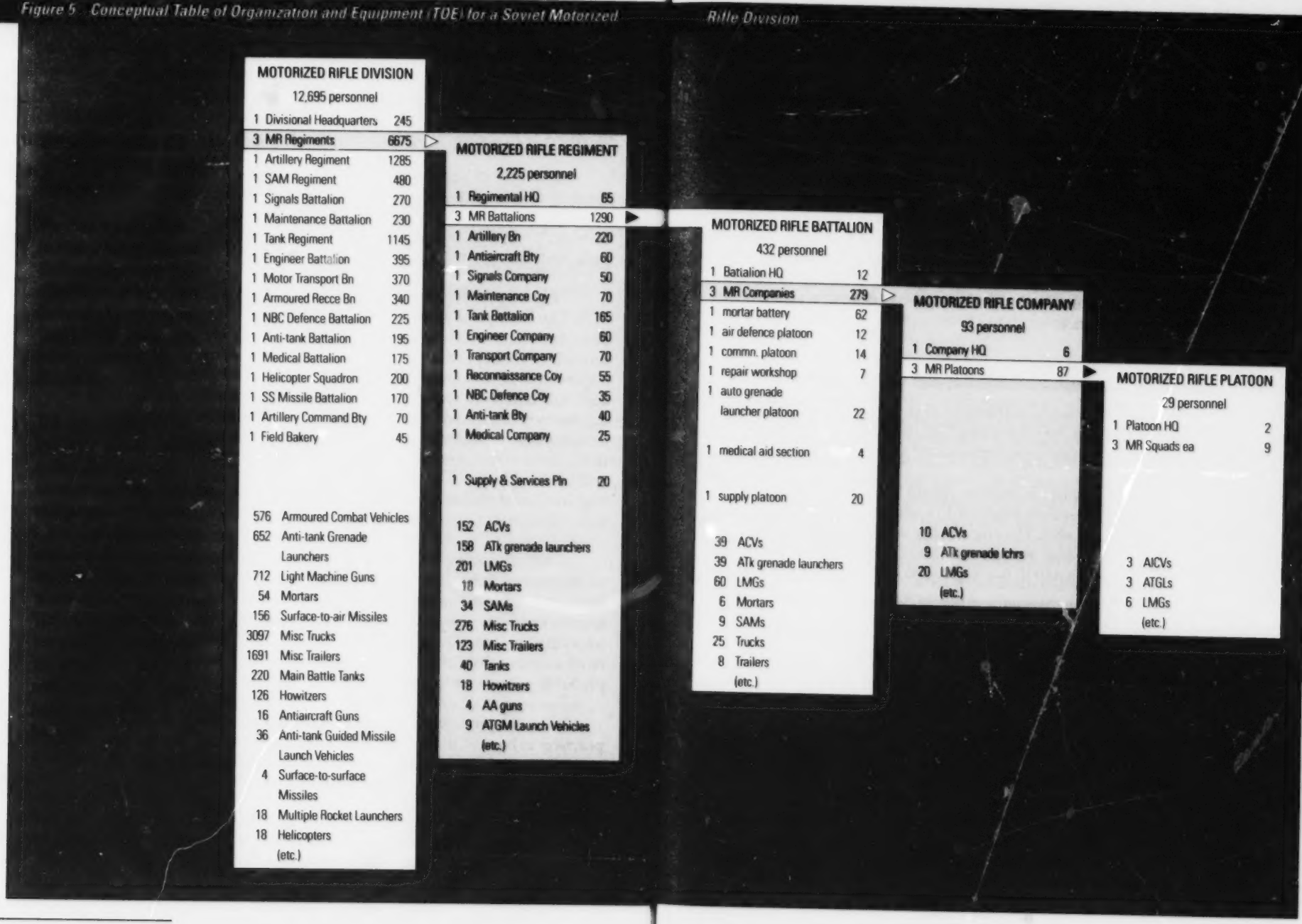
The TOE of large army formations contain an enormous amount of detail. No doubt familiarity with these details would aid an inspector in ascertaining whether a unit had about the same strength in personnel and equipment as had been declared, although the relationship between many of the items and the total personnel strength might be tenuous.

Figure 5 illustrates some of the information that is contained in a typical TOE. The example is a Soviet Motorized Rifle (MR) Division. Organization is described in terms of the sub-units which make up the division, with a further breakdown being given for a MR regiment of the division, a MR battalion of the regiment, a MR company of the battalion, and a MR platoon of the company. For each sub-unit there will be an authorized establishment for personnel, with examples being shown for motorized rifle, tank, and artillery sub-units. A detailed TOE would also specify the rank and trade of each individual member. In addition to the personnel, all of the equipment authorized for each sub-unit will be listed in the TOE. Figure 5 simply lists the categories of a few of the more important and visible items, but these would be specified by number and precise description, running to hundreds of pages.

A further complication is introduced by the fact that many units will not be manned or equipped up to their authorized TOE. In fact, some armies have a "war establishment" and a "peace establishment", the latter being well below the former, but with plans to enable it to be brought up to strength if necessary. An important product of verification would be the detection of significant reinforcement that brings units up to war establishment, even though this would probably not constitute a violation of an agreement.

For the purposes of aiding in verification it would not seem necessary or practical to have TOE declared down to extreme detail, or to expect parties to undertake to maintain the inventories exactly as listed in the TOE.

Figure 5 Conceptual Table of Organization and Equipment (TOE) for a Soviet Motorized Rifle Division



VI. Suggestions for Future Research

Before committing nations to agreements whose usefulness depends on adequate verification, many things should be known. One is the degree of verification considered to be "adequate". Another is the capability of various methods of verification to succeed to an extent commensurate with whatever criterion has been accepted as adequate. A third is the cost of providing the various forms of verification. A fourth is an assessment as to whether the intrusiveness and nuisance of the different types of verification is going to be acceptable to all parties.

There is little relevant past experience with verification of conventional arms control agreements on which to draw, and even less for limitations on personnel. Much could be learned from well-designed realistic trials. Two types of practical experiment appear worthy of consideration at this time: one of OSI and one of space-based surveillance.

Field Tests Using OSI for Personnel Verification

The most extensive field trials of verification of conventional arms control involving personnel carried out so far were *Cloud Gap* and *First Look* in the 1960s. The results concluded from the trials were summarized above.

In planning a program of trials, a decision would have to be made as to whether to test verification of personnel alone, or to use the same trials to investigate verification of TLE as well. The advisability of incorporating other tests would depend on the additional complication and expense incurred, but this marginal cost could be quite small in comparison to the cost of mounting the trials at all.

As many as possible of the different methods of verifying personnel should be included in the trials, such as OSI, EEP, identification of individual personnel, use of remote sensing devices, and comparison of observations with declared data.

In deciding how much access to grant to inspectors, procedures for making declarations, logistics support, communications arrangements, and techniques of data collection, useful advice should be available from the recent experience gained in the verification of the INF Treaty, and from the plans for verifying the CFE Treaty.

Aerial inspection and space surveillance could be included. Inclusion of aerial surveillance should allow valuable information to be obtained relevant to

the Open Skies talks and CFE Treaty follow-up. It should be easy to divide the analysts into separated and isolated groups, allow one group access to the data from all of the airborne and spaceborne sensors, but oblige other groups to reach their evaluations with certain data denied them.

The organization being inspected should provide a TOE, a nominal roll of the military personnel in the location subject to inspection, including thumbprints, and ID Cards with photographs and thumbprints.

The OSI and portal monitoring teams should be provided with the equipment needed to take and compare fingerprints. It would not be necessary to include the capability for remote transmission of prints for the trial, although if this were available the trial would provide an opportunity to test it. Some personnel in the inspecting organization would have to have some expertise in fingerprint identification. It should be possible to obtain this expertise by using appropriately trained military security personnel, by seeking the assistance of police forces, or by sending military participants to a suitable course of instruction.

Several factors that should be tested would add considerable complication and expense to the trial, and the decision as to whether to include them would have to be taken when the resources available were determined. One of these is the significance of portal monitoring. It would be possible to have inspection at portals for only part of the entire trial, or to have some sites without portals. Another factor is the effect of deception in the data declared to the inspecting organization. It would be possible to have some of the TOE accurate and some intentionally false. Some ID Cards could have the name and thumbprint of an individual on the declared roll but the photograph of the (different) person carrying it. Or some non-declared soldiers could be issued ID Cards that were duplicates of those of a declared individual. Another form of deception that certainly ought to be tested would be concealment of personnel.

Each additional variation introduced into the trial should produce valuable insight as to what could be done in a real operation, but in order to obtain reliable conclusions each additional item would probably add to the expense of the trial and the complexity of the analysis.

Field Testing of Satellite Surveillance for Personnel Verification

An image taken from an overhead surveillance device will not permit the counting of individual persons unless the resolution is of the order of 20 cm. This can be obtained by photography taken by aircraft, and is almost certainly within the limit of resolution obtainable by the most advanced American or Soviet

optical surveillance satellites. Radar is not able to attain resolution as high as can be achieved by optical sensors, although it is improving rapidly.

However, as discussed above, observation of objects much larger than humans (vehicles, tanks, guns, buildings, facilities on a military base, etc.) may provide valuable clues as to the number of personnel associated with them. Satellite imagery commercially available on the open market now offers images with resolution good enough to identify large objects such as buildings, and may well be able to detect the presence of groups of vehicles or similar smaller objects. The quality of these images is being improved year by year[31], and studies done in Norway, Japan and Canada have shown that a surprising amount of information can be deduced from images of comparatively low resolution. An indication of the usefulness of comparatively low resolution imagery for the gathering of intelligence was given by the action of the USA government, in 1978, of issuing a national security directive limiting the resolution of civilian satellites to 10 m. This directive was rescinded in 1988, stimulated by the desire for the USA to be able to offer commercial competition to satellites being designed by other countries and able to achieve resolutions better than 10 m.

A useful experiment for personnel verification might be to contract for a series of commercial satellite images of certain military bases, to be taken at agreed times. In some cases activity on a cooperating base should be controlled as part of the trial, including the holding of parades, assembly of vehicles, tanks and guns, and the conduct of exercises, all scheduled to occur at the time the satellite passes overhead. Cooperating bases, including some not altering their activity because of the trial, should maintain records of events at the time of the satellite overflight, perhaps aided by the presence of an observer from the trial team. However, imagery could also be purchased at bases or other military facilities which did not participate in the trial.

There would be considerable advantages to the simultaneous and coordinated operation of both of these trials suggested above (i.e. OSI and satellite observation), but this would introduce complications and constraints which might not be worth accepting. A minimum degree of combination could be to buy commercial satellite imagery of the bases at which trial OSI were being conducted, to be taken at or close to the time of the inspections.

Further Exploration of Verification Using Personnel Records

Another approach meriting further consideration focuses on the audit of military personnel records. The basic rationale underlying this approach rests on the belief that all countries in Europe, and most in the world, must maintain records of their military personnel for their own administrative purposes. Pay records are a prime example of this; undoubtedly there are others. Because this

paper trail already exists for each country, it may be possible to "piggy back" a verification system upon national records.

An analogy can be drawn with the International Atomic Energy Agency (IAEA) Safeguards system, which involves essentially the requirement to establish national accounting systems for the nuclear material under control that meet international standards developed by the IAEA. Countries, of course, require such a national records system for their own purposes (primarily safety concerns). Data deriving from this national system is regularly reported to the IAEA, which also "checks the books" at facilities subject to Safeguards. In addition, the Agency can undertake OSI to check the accuracy of these national records as well as implement containment and surveillance methods to assist in monitoring the nuclear material.

As demonstrated by the recent findings of the UNSCOM/IAEA inspections concerning surreptitious Iraqi nuclear weapons programs, the traditional IAEA Safeguards approach (which had been applied to Iraq without detecting the illicit programs) can not provide the complete solution to verifying compliance with the Non-proliferation Treaty. Improvements to Safeguards are needed, notably greater emphasis on short-notice "special inspections" at declared and undeclared facilities. Nevertheless, traditional Safeguards will continue to constitute an important element in any effective verification regime. Similarly, records monitoring for military personnel could well be a valuable component of a verification regime in that context.

There is, of course, a world of difference between record keeping for nuclear material and that for military personnel. Nevertheless, the fundamental analogy of an international audit of nationally maintained records supplemented by periodic OSI by the international verifiers to check both the "books" and the items subject to control (in this case military personnel at units and bases) seems to be sound and worthy of closer examination.

Problems can be foreseen with this approach, however. The quality and format of the relevant national records will likely vary profoundly between countries. Whether it is possible to develop international standards for such records, which could be met by all countries, is uncertain. Alternatively, whether it is possible to "customize" international verification procedures to the unique workings of each nation's records keeping is equally uncertain. Nor can it be foreseen, without expert research, whether there exist key points in the records keeping trail or particularly useful types of records upon which to concentrate verification activities. Costs of implementing such an auditing procedure are equally unclear, though it may be possible to reduce costs through the clever use of random sampling. Traditional concerns about intrusiveness must also be addressed.

Despite these caveats, there does appear to be enough merit in the idea to justify further investigation. In this context, expert advice might be sought from the financial auditing profession. It would be extremely valuable to involve auditors from the military at some point, because of their unique knowledge of military records keeping, as well as someone familiar with IAEA procedures.

Possible linkages between this audit approach to personnel verification and the UN reporting system on military budgets might also be the subject of investigation. Monitoring military personnel records for verification purposes would, of course, require considerably more detailed exchange of information, but the complementarity of these two ideas could be significant.

Further Exploration of Verification Using Identity Cards

As is true for the auditing approach, there would seem to be merit in further examination of the MILPER card idea or similar "tagging" schemes. While, again, such an approach to personnel verification would not constitute a comprehensive solution to the problem, it might well be a useful component of such a solution. In addition, the scheme could have valuable confidence building dimensions, in its own right.

Such a preliminary investigation would focus on technological, financial and organizational feasibility. Critical thought would need to be given to how effective such a scheme would be for verification of personnel limitations.

Examination of Improvements to Existing Information Exchange and Verification Procedures

The provision of relatively detailed data respecting the TOE of military units would be particularly beneficial in monitoring personnel levels. It is the accuracy of this enhanced TOE data that might be verified by short notice OSI, the use of remote sensors as well as perhaps EEP in some circumstances. The examination of military records and accounts might help as well, though using this method alone would be vulnerable to deception. Important indications of unit strengths could also be derived from information on the numbers of larger, more readily observable objects such as tanks and other vehicles, buildings, and other items present on military bases. Indeed, the process would be analogous to the traditional construction of orders of battle by military intelligence.

There would seem to be several possibilities concerning changes to CFE Treaty and Vienna Document information exchange and verification procedures, deriving from this analysis that might warrant further consideration:

1) The provision of detailed data on military TOE might include exchanges that provide personnel strengths for all military units below the brigade/regiment level as well as support personnel at military bases. Such an enhanced data exchange could be seen as a confidence building measure in its own right.

2) Relatively modest adjustments to CFE Treaty style OSI procedures could enhance the ability to verify personnel limitations, particularly enhanced data concerning TOE. Things as simple as allowing CFE inspectors in the course of an inspection to check barracks and messing facilities to determine their usage might be helpful. Cooperative measures like giving advance notification and perhaps having inspectors present when a military unit is put on parade might also help.

3) Another change to CFE Treaty style inspections that could assist in monitoring personnel levels would be to extend inspection rights (apart from challenge inspections) to cover military units which do *not* hold TLE.

4) It might also be useful if a certain number of units/bases each year could be randomly inspected in considerably great detail to ascertain personnel strength. The intensity of such inspections might have to be considerably greater than for CFE Treaty OSI or "evaluation visits" under the Vienna Document. Costs and inconvenience would be correspondingly higher, suggesting that, while such personnel oriented OSI would be more thorough, they should be fewer in number.

5) Provisions allowing the inspection of unit/base records might also facilitate personnel verification and might be combined with regular or random OSI. There will, of course, be variations in the quality and format of record keeping between nations that will have to be taken into account.

None of these possibilities would seem to involve major difficulties if implemented or constitute major threats to the security of parties. They could, however, contribute significantly to personnel verification as well as have positive confidence building implications. Further examination of such possibilities should be considered.

VII. Summary and Conclusion

Verification of arms control agreements becomes progressively more difficult as the objects limited by the agreement become smaller, more mobile, more numerous, and accompanied by more "look-alikes". As the objects become more difficult to detect, identify, and count by remote sensing, and more difficult to distinguish from similar objects that are permitted by the agreement, effective verification depends to a greater level on cooperative measures such as OSI and declarations of locations, units, and identities of personnel. These will pose increasing degrees of intrusiveness and nuisance, concerns for the protection of sensitive information, and expense for all parties.

The sequence of difficulty begins with the large permanently sited missiles, submarines, and heavy bomber aircraft, limited by the SALT agreements, and proceeds to the mobile missiles of the INF Treaty. The next stage is provided by the smaller, mobile, and numerous conventional weapons permitted by the CFE Treaty. Verification of military personnel will be the most difficult, since the objects of limitation (i.e. military servicemen) are small, mobile, easily concealed, and easily mistaken for look-alike permitted items. The permitted numbers will be very large, and it will not be possible to attach permanent tags to them, or to witness their removal from active service.

It may be possible to use information about large observable objects (such as major weapons, buildings, vehicles, and other items on military bases) to deduce the associated personnel strength. Such methods would be aided by truthful declarations of the TOE of military units, and of the locations of the units. Periodic and short notice inspections on a random basis would help confirm the accuracy of such declarations.

Estimates of the number of weapons or other equipment declared in TOE and observable by NTM or OSI may thus serve as a surrogate for direct counting of personnel. This method does, however, present the possibility that significant personnel and combat capability could be added without a corresponding increase in the number of observable objects of the types declared.

A serious problem arising with respect to the limitation of military personnel (and its verification) is the determination of which categories of paramilitary and police organizations are to be excluded from limitation.

While examination of budgets and personnel records may provide useful verification of personnel strength when there is no effort at concealment or evasion, this method is vulnerable to deception. Nevertheless, it might be useful to allow on-site inspectors access to base accounts as part of their other duties.

The most useful means of verification are likely to be OSI, both ground-based and airborne. These OSI should include a proportion announced with very short notice, and a proportion conducted at locations other than declared sites. In both cases, measures should be put in place to detect rapid evacuation of personnel before the inspecting team or aircraft arrives at the site.

In addition to brief visits, it may be necessary to have some inspectors stationed at certain sites, perhaps at EEP. This latter measure implies the erection of a security fence around the site. Alternatively, tamper-resistant sensing devices might be employed in some cases. The possibility of assigning liaison officers to units, who would be permitted to become familiar with personnel levels, might also be worth serious consideration.

The ability to identify individual military personnel would be of major assistance to the verification of personnel limits. This may be possible through some scheme using personal ID Cards bearing fingerprints, and accompanied by transmission of copies of the ID Cards to the verifying organization. Even more helpful would be the declaration of the nominal rolls of units.

As is true in a number of other verification contexts, the most effective verification regime is likely to be one which employs a number of different, mutually-reinforcing methods.

Although any international organization for verification will probably lack sophisticated remote sensors, nations should and surely will employ their own resources to combine information from all available sources, in order to arrive at their judgements as to whether other nations are complying with their agreements.

Provision of the data needed for effective personnel verification could impose a considerable administrative burden and associated costs, as could the process of conducting inspections and analysis.

Not very much has been written, or research done, at least as reported in the open literature, about the problems of verifying limitations on military personnel. Areas for further useful research might include the following:

- Field trial(s) of the application of OSI as well as other verification methods (e.g. aerial inspections, EEP, and satellite imagery);
- Further exploration of the utility of monitoring military personnel records;
- Further exploration of special military ID Cards; and
- Further examination of modest changes to CFE Treaty and Vienna Document requirements for declarations of information and

inspection procedures, that could enhance the ability to verify personnel limitations.

In conclusion, the level of effort devoted to personnel verification should be dependent ultimately on a careful assessment of the importance of limitations on military personnel. If the collective judgement of the parties to an agreement is that personnel limitations are not significant to their security, then the verification effort should be commensurate. Conversely, if such limitations are seen as important, then the level of verification effort should reflect this assessment. Unfortunately, it does not always seem to be an evaluation of the security importance of personnel limitations that has driven judgements about what level of verification should be pursued. Rather, there is a danger that the perceived difficulties, costs and inconvenience of verifying personnel limitations is precluding serious discussion of verification in this context.

The current "conventional wisdom" holds that verifying personnel is, for all practical purposes, impossible. This view may be correct. But it behooves us, because of the potentially serious political and military importance of disputes over compliance with obligations respecting personnel limitations, to examine rigorously all possible approaches for effectively verifying such compliance.

Notes

1. UNGA Resolution A/RES/43/81(B), 7 December 1988. The text of the Sixteen Verification Principles can be found in: United Nations General Assembly, "Report of the Disarmament Commission", UN Document A/S-15/3 (New York, 1988), pp. 44-46.

2. Western European Union, *Past Experiences of Verifying Restrictions on Conventional Forces and Armaments* (Paris, March 1988).

3. *Ibid.*, pp. 6-7.

4. *Ibid.*, pp. 7-15.

5. United States, Department of State, and Arms Control and Disarmament Agency, *Documents on Disarmament*, 1945-1982.

6. "United States Paper Submitted to the Working Committee of the Commission for Conventional Armaments: General Views on the Nature and Scope of "Military Safeguards" — Information on Military and Paramilitary Establishments to Be Reported, Inspected and Verified, July 13, 1950", *Documents on Disarmament*, Vol. 1 (1945-1959), pp. 240-246.

7. "United States Working Paper Submitted to the Disarmament Commission: Proposals for Progressive and Continuing Disclosure and Verification of Armed Forces and Armaments, April 5, 1952", *Ibid.*, pp. 353-354.

8. See: Patricia Lewis, "Verification Experiments in the 1960s: from *Cloud Gap* to Exercise *First Look*", in *Verification of Conventional Arms Control in Europe*, ed. R. Kokoski and S. Koulik (Boulder, Colorado: Westview Press, 1990), pp. 239-252.

9. See: *Ibid.*; and United States, Arms Control and Disarmament Agency, *Inspection and Observation of Retained Levels of General Purpose Ground and Air Forces in a Specified Area (UK): Summary Report (Field Test FT-15, Exercise First Look)* (Washington: February 1970).

10. WEU, *Past Experiences..., supra*, p.31.

11. Lewis, *supra*, p. 251.

12. See: David Barton, Sigrid Pöllinger, and Ulf Reinius, "Negotiations for Conventional Force Reductions and Security in Europe", in *World Armaments and Disarmament: 1983*, SIPRI (New York: Taylor and Francis, 1983), pp. 595-608; Reinhard Mutz, "MBFR: Problems and Lessons", in *Quantitative Assessment in Arms Control*, ed. R. Avenhaus and R. Huber (New York: Plenum, 1984), pp.93-128; and Michael Sheehan, "A More Inane Congress: Twelve Years of MBFR", *Arms Control*, Vol. 6, No. 2 (September 1985), pp. 150-159.

13. See: Brian S. Mandell, "The Sinai Model: Lessons in Multimethod Arms Control Verification", in *Back to the Future: Lessons from Experience for Regional Arms Control and Verification*, ed. Brian S. Mandell (Ottawa: Carleton University, 1989), pp.51-80; *Idem., The Sinai Experience: Lessons in Multimethod Arms Control Verification and Risk Management*, Arms Control Verification Study No. 3 (Ottawa: Department of External Affairs, 1987); and Sergey Koulik, "The Sinai Experience", in *Verification of Conventional Arms Control in Europe*, ed. R. Kokoski and S. Koulik (Boulder, Colorado: Westview, 1990), pp. 217-228.

14. See: *Vienna Document 1990 of the Negotiations on Confidence-and Security-Building Measures Convened in Accordance with the Relevant Provisions of the Concluding Document of the Vienna Meeting of the Conference on Security and Co-operation in Europe* (Vienna: 1990).

15. *Ibid.*, paragraphs 112-142.

16. Terms were taken from *The Military Balance 1990-1991* (London: Institute of International and Strategic Studies, 1990).

17. See: *Soviet Military Power 1990* (Washington, D.C.: US Department of Defense, 1990), p. 75.

18. See: *The Military Balance 1989-1990* (London, International Institute for Strategic Studies, 1989), pp. 240-246.

19. *Vienna Document*, paragraphs 14-16.

20. United Nations General Assembly, Resolution RES/40/91/B of 12 December 1985.

21. Recognition that access to certain sensitive areas will have to be denied is demonstrated in paragraph 86 of the *Vienna Document*. Limits are also imposed upon inspector access to "sensitive points" under the CFE Treaty; see, for example, *Protocol on Inspection*, Section VI, paragraph 28.

22. See: Caesar Voute, "The Use of Satellites for Verification", in *A Handbook of Verification Procedures*, ed. F. Barnaby (London: Macmillan, 1990); M. Krepon, *et al.*, *Commercial Observation Satellites and International Security* (New York: St. Martins, 1990); Richard Kokoski, "National Technical Means", in *Verification of Conventional Arms Control in Europe*, ed. R. Kokoski and S. Koulik (Boulder, Colorado: Westview, 1990), pp. 17-55; and Johnny Scorve, "Commercial and Third-Party Satellites", in *ibid.*, pp. 56-88.

23. See Hartwig Spitzer, "Aerial Observation and Overflights", in *Verification of Conventional Arms Control in Europe*, SIPRI (Boulder, Colorado: Westview Press, 1990), pp. 89-122; Allen V. Banner, Andrew J. Young and Keith W. Hall, *Aerial Reconnaissance for Verification of Arms Limitation Agreements: An Introduction* (New York: United Nations Institute for Disarmament Research, 1990); and Michael Slack and Heather Chestnutt, ed., *Open Skies: Technical, Organizational, Operational, Legal and Political Aspects* (Toronto: York Centre for International and Strategic Studies, 1990).

24. See: Jurgen Altmann, "Short-distance Sensors", in *Verification of Conventional Arms Control in Europe*, ed. R. Kokoski and S. Koulik (Boulder, Colorado: Westview Press, 1990), pp. 123-138.

25. Complications can occur for considerations such as troops for defence of airfields, naval bases, or coastal defence. These are necessary functions, associated with general-purpose air forces and navies, but less closely related to the number of aircraft or ships, and bearing close similarity to the functions of armies.

26. In the United States Army an armoured division has six tank battalions and four infantry battalions. In a mechanized division the ratio is reversed to four tank and six infantry battalions.

27. Numbers are taken from the International Institute for Strategic Studies, *Military Balance, 1991-1992*. Divisions labelled as "mechanized" or "motorized rifle" are considered to be "infantry". "ACV" include the CFE categories of Armoured

Infantry Fighting Vehicles and Armoured Personnel Carriers. Artillery pieces include guns, howitzers, and mortars of calibre 100 mm or more, as well as multiple rocket launchers.

28. The authors are indebted to Mr. John Dendy of External Affairs and International Trade Canada for this suggestion and its elaboration.

29. The authors are indebted to Mr. Jeff Tracey of External Affairs and International Trade Canada for this suggestion.

30. The CFE Treaty specifies brigade/regiment, independent battalion, wing/air regiment, independent squadron or their equivalent. The *Vienna Document*, which unlike the CFE Treaty does require data on peacetime authorized personnel strength to be exchanged, focuses on brigade/regiment or equivalent level and wing/air regiment or equivalent level.

31. The American Landsat 5 has demonstrated photographic resolution of 30 m; French SPOT-1, 10 to 20 m; and a Soviet satellite, about 5 m. American EOSAT predicts 5 m; Swedish Tellus, 2 m; and a USSR satellite, 2 m. Satellites with synthetic aperture radar have not yet obtained such fine resolution, but the European Space Agency's ERS-1 hopes for 25 m and Canada's RADARSAT, 10 m. See: Johnny Skorve, "Commercial and Third-Party Satellites", in *Verification of Conventional Arms Control in Europe*, ed. R. Kokoski and S. Koulik (Boulder, Colorado: Westview Press, 1990), pp. 56-88. Also: Hugh De Santis, "Commercial Observation Satellites and Their Military Implications: A Speculative Assessment", *Washington Quarterly* (Summer 1989), pp. 185-200.

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- As armed forces are reduced, limitations on personnel may become increasingly important for security and stability, especially in regional contexts.
- If the parties to an agreement believe that personnel limitations are important to their security, then the level of verification effort should reflect this assessment.
- "Conventional wisdom" holds that verifying personnel is, for all practical purposes, impossible. This may be true.
- However, there is a danger that the perceived difficulties, costs, and inconvenience of verifying personnel limitations is precluding serious discussion of verification in this context.

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